THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

WITH THE

PROCEEDINGS OF THE NATURAL HISTORY SOCIETY
OF MONTREAL:

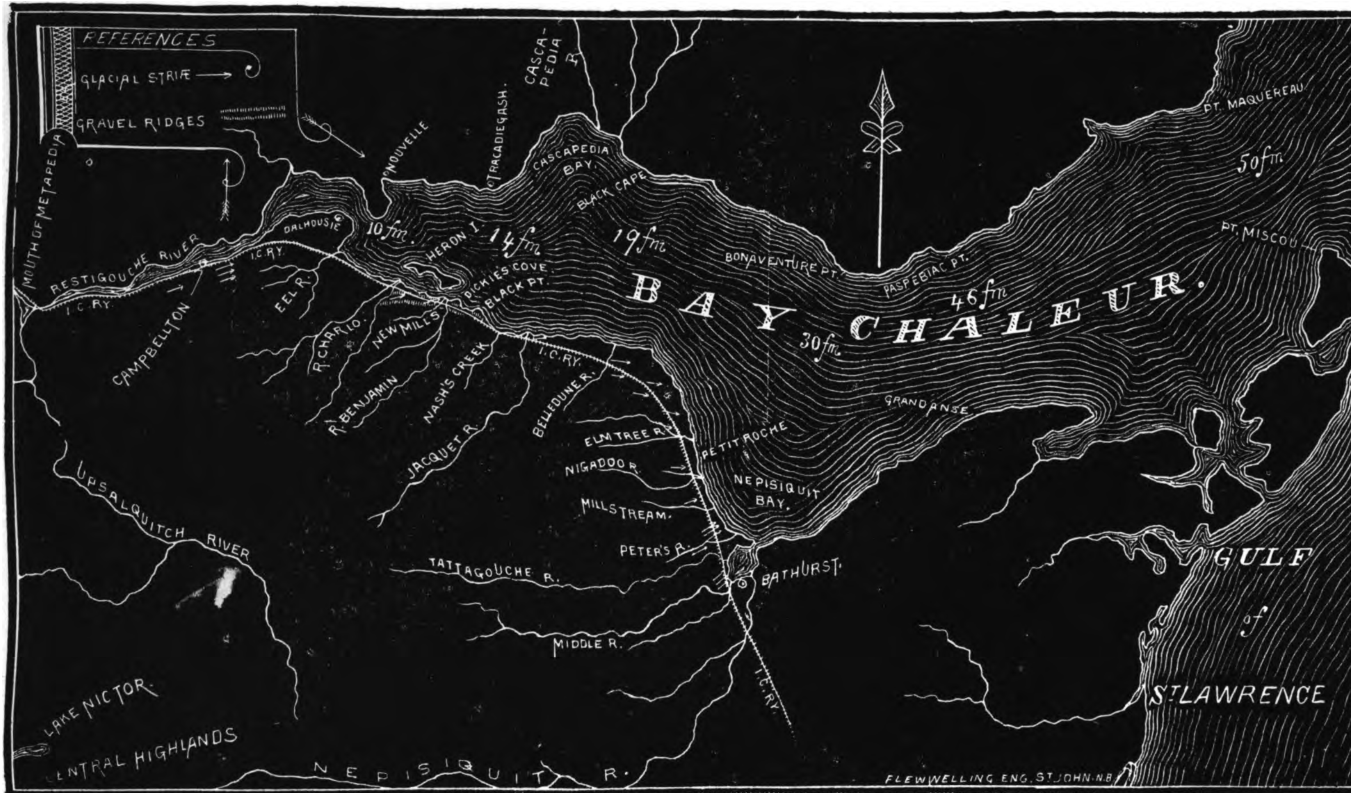
J. T. DONALD, M. A., - - EDITOR.

NEW SERIES—Vol. 10.

MONTREAL:
DAWSON BROTHERS, PUBLISHERS.
1883.

☞ The Editor of this Journal is responsible only for such communications as bear his name or initials.

CONTENTS.



MAP OF THE BAY CHALEUR REGION SHOWING GLACIAL STRIÆ, GRAVEL RIDGES, ETC.

(To illustrate article "On the Glacial Phenomena of the Bay Chaleur Region." See page 37 *et al.*)

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

PALÆONTOLOGICAL NOTES.

BY J. W. DAWSON, LL.D., F.R.S.

I. A NEW SPECIES OF PILOCERAS.

(Figs. 1, 2.)

This genus was established by Salter, in 1858,* for a very curious shell found in Scotland, in the Durness Limestone, one of the lowest members of the Lower Silurian or possibly within the limits of the Upper Cambrian. Salter found in this limestone two species of the genus, but one was too imperfect for description. The typical species *P. invaginatum* he regarded as the shell of a cephalopod mollusk allied to *Orthoceras*, but of very simple structure, having the chamber and siphuncle united into one organ. His definition of the genus was in these words: "siphuncle and septa combined, as a series of conical concave septa which fit into each other sheathwise."

In 1860, Billings described, in the *Canadian Naturalist*, † a species from the Calciferous Formation of Belleisle, under the name *Piloceras Canadense.* The specimens showed that the part described by Salter was not the external shell, but only the siphuncle, and that the shell, when complete, must have included a chambered portion surrounding this enormous siphuncle, which thus corresponded to the great siphuncle of the Lower Silurian shells known as *Endoceras.* Having thus ascertained the exist-

* Journal of Geological Society of London, Vol. XV.
† Vol. V.

ence of external chambers, Billings supposed that the sheathing divisions of the interior described by Salter had been filled with a solid deposit of carbonate of lime, so that this curious shell would seem to have had a sinker as well as a float. The specimen now to be described shows that this was probably an error, and that the shell had a double series of chambers, and was thus not a very simple form, as supposed by Salter, but really a shell of great complexity. Billings afterwards described three additional species from the Quebec group of Newfoundland.

Fig. 1.—Siphuncle of *Piloceras amplum*, natural size, from a photograph. The chambers are seen in part on the stone at the lower side, but have not been correctly given by the engraver.

The present specimen was found in the Calciferous sandstone, a few miles south-east of Lachute, by Mr. Macpherson, a member of my class in Geology, in the course of an excursion to that neighborhood last autumn. It represents a species quite distinct from those described by Salter and Billings—probably an adult individual—and it illustrates in a very interesting manner the complex structure of this remarkable group of shells.

The siphuncle, which wants a portion of the apex, is a flattened cone, which, when complete, must have been about 5½ inches in length, and 2½ in its greatest diameter. It is marked, in the portion preserved, with about twelve diagonal ribs, indicating the lines of attachment of the partitions of the external shell, of which only portions of a few remain attached to the surface at one side. The lower part of the shell is divided by a vertical partition crossing its longer diameter. At the top this splits into a flattened cone, somewhat flatter than the siphuncle itself, and more obtuse, so that at the top it joins and unites with the rim of the siphuncle, The space below this inner cone is that supposed to have been solid; but in the present specimen it is filled with calcite, showing that it must have been an enclosed space. Farther the vertical partition presents, in section,

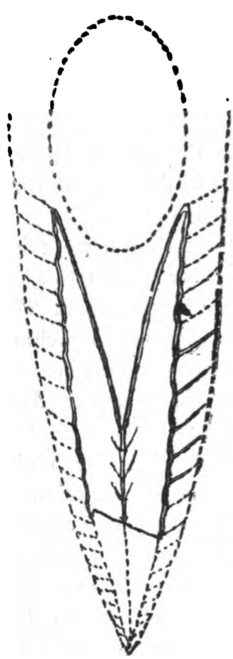


Fig. 2.—Transverse and restored vertical sections of *Piloceras amplum* reduced. The upper figure shows the proportions of the cross section. The lower figure is a section in the direction of the shorter diameter, showing the conical siphuncle, the siphuncular cavity, with remains of partitions, and the external chambers. The dotted lines are restored portions.

a series of swellings or ridges, and to these are attached the remains of what seems to have been membranous partitions, which must have formed successive interior cones as the siphuncle grew in size, terminating in the final one, which became completely calcified.

It would thus appear that the shell had a wide conical siphuncle which, as it grew in height, it partitioned off, with flattened cones within. The effect would be to give protection to whatever part of the body extended back into the siphuncle, to give great strength to the shell, and to form a double series of air chambers, that within the outer shell and that in the apex of the conical siphuncle, by which great buoyancy would be secured.

As Salter has already remarked, this shell has affinities with such shells as *Cameroceras* and *Endoceras*, though in magnitude of siphuncle it exceeds these types, as well as possibly in the property of possessing a double series of air cells. It is, however, not improbable, from the manner of the filling of the partitioned parts of the siphuncle of *Endoceras*, that this also was hollow in the living state.

I would propose for the present species the name *Piloceras amplum*, with reference to the great width of the siphuncle. Its description will be as follows :

Length of siphuncle, 12 centimetres ; longest diameter at the top, 6 centimetres : shorter diameter, 3.5 centimetres ; greatest angle of divergence of siphuncle, about 27°. Siphuncle annulated with raised lines, marking the attachment of the septa of the exterior shell. These lines are inclined to the axis of the shell at an angle of about 20°. They are, however, slightly curved and on the dorsal (?) side of the shell bend slightly downward. The internal cone of the siphuncle is 5 centimetres in depth. It is flatter than the siphuncle, ending at the apex in an edge, which is attached to a central shelly plate crossing the lower part of the siphuncle. This plate shows, at intervals, slight projections giving rise to delicate internal cones apparently membranous. The space between the inner cone and the wall of the siphuncle must have been empty and closed, as it has been filled not with the surrounding coarse dolomite, but with calcite, introduced by infiltration. Whether the siphuncle was central or lateral does not appear. There are, however, distinct marks of the partitions of the chambers all around it.

II. SACCAMMINA ? (CALCISPHÆRA) ERIANA.

(An Erian Rhizopod of uncertain affinities.)

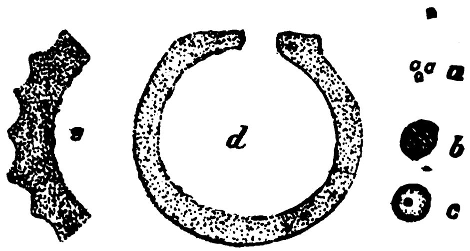


Fig. 3.—*Saccammina Eriana.* (*a*) natural size ; (*b*) magnified, showing sculpture ; (*c*) magnified, showing aperture ; (*d*) section magnified, showing aperture ; (*e*) section of portion of wall more magnified, showing structure.

Several years ago, specimens were sent to me by my friend Dr. Newberry, of New York, of a curious organism from the Devonian (Corniferous) limestone of Kelly's Island, near Sandusky, Ohio. They are minute globular bodies, one millimetre in diameter, and occur in great numbers in light gray limestone containing *Stromatopora*, crinoidal joints and corals, as well as multitudes of minute organic fragments. The exterior surface of the specimens is dull or granular in aspect, and either smooth or marked with slight spiral ridges, giving an appearance which at first sight suggests a resemblance to the spore-cases of *Chara*. On microscopic examination, they are found to be hollow spheres filled with calcite introduced by infiltration, having one small aperture ; and the test or wall of the sphere presents a granular appearance as if composed of fine calcareous grains. Understanding that Dr. Newberry desired a note for publication in his Reports on the Survey of Ohio, I prepared and sent to him the following description, which, however, I have not yet seen in print :—

" *Saccammina Eriana.*—Test globular, about one millimetre in diameter, with one aperture. Wall composed of minute calcareous grains, smooth interiorly, on the outside smooth, irregular or fluted longitudinally. Corniferous limestone near Sandusky. Collection of Dr. Newberry.

" This little organism occurs in great numbers in whitish granular limestone, associated with fragments of crinoids and corals. Its test appears to be composed of very minute calcareous grains,

and it can scarcely be anything else than a Rhizopod, probably allied to the modern *Saccammina globosa*, or to the Carboniferous *S. Carteri*, though much smaller than either, and differing in its tendency to external ornamentation. It is of course possible that a test of this kind might belong to an animal of very different character from *Saccammina*, but in the present state of knowledge of such forms, I think it quite justifiable to refer it to this genus."

In the conclusion of the above note I referred to the chara-like form of the test, and to its entire difference of structure from any vegetable organism. At a subsequent date I obtained additional specimens from Mr. Walker, of Hamilton, Ontario; and in my paper on *Stromatoporidæ*, published in the Journal of the Geological Society in 1879, I referred to it, under the above name, as associated with *Stromatopora*, and sometimes overgrown by its layers.

In the course of last summer, I received from Prof. Williamson, of Manchester, Part X of his valuable Memoirs on the Organisation of the Plants of the Coal Measures, and was surprised to find my little fossil noticed therein, with a new name and in quite a new connection. It appears that some bodies of similar appearance, but much smaller, had been found by Prof. Judd in Carboniferous limestone in Wales, and that they had been referred to the group of Radiolarians. This reference was disputed, apparently on good grounds, by Prof. Williamson. He had examined them, under the impression that they might be of vegetable origin, but finally had supposed it more likely that they were animal and foraminiferal, and had assigned to them the non-committal name of *Calcisphæra*. They had also, in the course of the discussion as to their nature, raised the chemical question whether it was possible that silicious tests like those of Radiolarians could be replaced by carbonate of lime: a change which, though perfectly possible, and sometimes realised in Palæozoic silicious sponges, is in the highest degree improbable in the case of these bodies. In the course of this investigation, Prof. Williamson had received from our mutual friend Mr. H. B. Brady, F.R.S., specimens of the little fossil from Kelly's Island, which, I think, I had sent to him, and these were referred by Williamson to the same genus with the Welsh specimens and named by him *Calcisphæra robusta*. He described the species as follows;

"Each organism is a hollow sphere. The sphere-wall is much thicker in proportion to its diameter than is the case among the Welsh specimens. Externally the transverse section of each sphere presents an undulating outline due to the intersection of prominences and ridges that characterise its surface. Sometimes these surround the entire section, but more frequently they are absent from limited portions of the periphery. Occasionally these ridges may be seen pursuing an oblique direction like the bands crossing the nucules of a *chara*. The central cavity is always occupied by crystalline infiltrated carbonate of lime. Though the sphere-wall often exhibits a granular texture, I discover a radiating structure in a sufficient number of the specimens to convince me that in this respect they have closely resembled some of the Welsh objects."

This description differs from mine in two important points: (1) It does not recognise the aperture, which is of course not easily observed except when specimens can be completely detached from the matrix. It exists, however, and is surrounded by a slightly flattened space or rudimentary flange. I may add that the possesion of an aperture does not conflict with the filling of the test with clear calcite, as the same substance occupies the spaces between the fragments contained in the enclosing limestone. (2) The supposed fibrous character of the test does not appear in my specimens. They are decidedly granular, even when viewed under high powers, though there is occasionally a tendency to linear arrangement in the constituent grains, perhaps indicating a porous structure. I have examined many specimens both by reflected and transmitted light, and feel confident that there is no truly radiating structure either of tubes or pillars. Farther, the minute grains of the test are similar in size and appearance to the more minute fragments visible in the matrix; and I cannot doubt that the test is granular and arenaceous, though it is of course possible that this granular texture may be a result of re-arrangement of particles in the process of fossilization. This, however, I do not think at all probable.

On the whole, I see no reason to depart from the conclusion that the organism in question is the test of a foraminifer, and this seems also to be the opinion of Williamson and Brady, who are the best possible authorities on such a question.

With regard to affinities, the flange-like orifice suggests relationship to the *Lagenæ*, while the globular form resembles

Orbulina, and the arenacous character suggests nearness to *Saccammina*, which also approaches most nearly in geological time. The ridged surface is no doubt unusual in arenaceous tests, but a tuberculated surface is found in some, as, for instance, in that from the Challenger dredgings recently described by Brady, under the name *Thurammina papillata*. The name *Calcisphæra* would be unobjectionable, were it not for the difference of structure in the test of the forms referred to this genus, and which on this account appear to me to be possibly of different nature. In the mean time, therefore, I leave the question of name as it stands at the head of this notice.

NOTE. (March 14, 1881.)—In a letter just received from Mr. H. B. Brady, he says that he knows of no rhizopod test recent or fossil, precisely corresponding to the little Erian fossil above described. He says—" the more I examine your little fossil the more confident I am that it bears no relation to any rhizopod type that I know." It will thus appear that he does not admit its affinity to *Saccammina*, and that he even doubts as to its rhizopodal character.

III. NEW DEVONIAN PLANTS FROM THE BAY DE CHALEUR.

The following notes relate to the examination of plants collected by Mr. A. H. Foord, of the Geological Survey, at Scuminac, opposite Dalhousie, and by Mr. Weston, of the Geological Survey, near Campbellton.

Mr. Foord's collections are from the Sandstones containing *Pterichthys Canadensis* Whiteaves, and other fossil fishes, and which appear in a low anticlinal form overlaid unconformably by a great thickness of red sandstone and conglomerate of the Bonaventure Formation (Lower Carboniferous). The beds seen at this place are characterised by their fauna, as of Upper Erian (Devonian) age.

1. *Archæopteris Gaspiensis*, s. n.

Barren pinnæ densely leafy, with the pinnules broadly obovate and somewhat truncate at the apex, decurrent by a broadish base on the somewhat stout striated petiole, veins forked thrice and strongly curved toward the lower edge. In luxuriant fronds the pinnules are 2.5 centimetres long and 1.8 centimetre broad.

Fertile pinnae with about twelve pinnules, each having a long midrib with about 7 pairs of crowded oblong spore-cases about 3 millimetres in length, pointed or somewhat obtuse at top, straight at the sides and apparently dehiscent at the apex. The midrib projects some distance beyond the spore-cases.

This species differs from *A. Jacksoni*, Dn., in the arrangement of the spore-cases, which are also larger and more oblong, and the barren pinnules are broader. It differs from *A. Hibernicus*, Brongt., in the arrangement and form of the spore-cases and in its shorter pinnæ, with fewer and less obtuse pinnules. It differs from *A. minor*, Lesquereux, in the arrangement of the spore-cases, which in the latter are in groups of three and of larger size, while the barren pinnules are much narrower. The present species resembles *A. Maccoyana*, Goeppert, in the form of the pinnules, but the fructification of the latter species is not known, and it may be merely a varietal form of *A. Hibernicus.* The present species is no doubt that referred to in my report on the Devonian plants of Canada as found in the Gaspé sandstone,* but the fragments known at that time did not enable me to separate it from *A. Jacksoni.* It is for this reason, as well as because the beds in which it occurs at Bay de Chaleur represent the upper part of Logan's Gaspé sandstones, that I have given it the name *Gaspiensis.*

Ferns of this type are characteristic of the Upper Erian on both sides of the Atlantic, and do not occur in the Carboniferous proper; though forms resembling them occur in the lowest Carboniferous beds.

2. *Cyclopteris obtusa,* Lesquereux.

I refer to this species a large and beautiful fern, which is obviously identical with that from the Cattskill of Montrose, Pennsylvania, figured by Lesquereux in the "Coal Plants of North America" (Report of Pennsylvania Survey), pl. 49, fig. 7, and of which I have a specimen in my own collection from the same formation at Franklin, New York.

This species is characterised by very large obovate leaflets decurrent by a long narrow base upon the petiole. Whether it was a pinnate or bipinnate frond does not appear. The veins are fine, curved and several times forked. The terminal leaflet is cuneate and emarginate. Some of the large pinnules are 6 cen-

* Page 487.

timetres in length. This fern is referred by Lesquereux to my genus *Archæopteris*; but as its fructification is not known, and as this forms the most distinctive character of *Archæopteris*, I think it better to leave the species in the provisional genus *Cyclopteris*.

One of my plants from the Devonian of St. John is referred to Lesquereux's species *C. obtusa*. The identification was made on the evidence of the figure and description in Rogers' Report on Pennsylvania, which refer to a much smaller fern than the present species, with the pinnules somewhat different in form and attachment. As Lesquereux, however, applies his name to the large species now under consideration, which is certainly distinct from the St. John fern, I must withdraw the name from the latter. In doing so, I may take advantage of a suggestion made by Schimper, who thinks that the St. John species might be placed in the genus *Aneimites*. It may accordingly be renamed *Aneimites obtusa*, which will at least prevent confusion.

Cyclopteris Brownii, Dawson.

(Report on Fossil plants of Devonian and Upper Silurian, p. 48, fig. 172, Journal of Geological Society of London, vols. xvii and xix.—Figures and description.)

This beautiful fern was previously known only from Perry in Maine, where it occurs only rarely and in detached leaves. Mr. Foord's specimens shew its habit of growth in dense clusters of fronds attached to what appears to be a creeping rhizome with slender rootlets. It has evidently been a low-growing species, its flabellate leaves attached by somewhat broad bases to a rootstock probably prostrate. Unfortunately no fructification appears, so that the plant cannot be compared with modern species having the same habit of growth. I may state, however, that the veinlets widen and become more dense in approaching the outer margin of the frond in a manner which seems to indicate that the fructification was marginal, in the manner of the *Pterideæ*.

It seems probable that the fern from the Upper Devonian of Pennsylvania figured by Lesquereux in Fig. VII, p. 50 of the Coal Plants of N. America is identical with this species. He refers it to *Rhacophyllum* of Schimper, with the specific name *R. truncatum*, which will, in this case, be a synonym of *C. Brownii*. The genus *Rhacophyllum* is very loosely defined by

Schimper, and is evidently provisional, including, according to him, young or basal fronds of ferns referred to other genera. As there is no evidence of this in the case of the present species, I see little advantage in removing it from the equally provisional genus *Cyclopteris*, until its fructification shall have been discovered. Should it, however, be considered desirable to remove it from *Cyclopteris*, I would propose for it the name of *Platyphyllum*, for which the characters of this plant as given in the paper above cited and in this note may suffice as generic characters.

Caulopteris (?)

Among Mr. Foord's specimens is one that appears to represent the stem of a small tree fern. It is about one inch in diameter, flattened and showing on the exposed side somewhat reniform scars quincunctially arranged. The best preserved leaf-scars show marks of vascular bundles which suggest the idea that it may have given origin to the petioles of ferns; but there is nothing to indicate whether this stem belongs to either of the species found with it.

Plants from Campbellton.

Mr. Weston's collections are contained in a hard argillaceous sandstone or arenaceous shale resembling some of the beds of the lower part of the Gaspé sandstones, with which the flora also agrees.

The greater part of the vegetable remains collected by Mr. Weston are stems and branches of *Psilophyton princeps* and *P. robustius*, which are very abundant. There are also a few leaves of *Cordaites angustifolia*, and in the same shale with some of these, is a short stem with remains of alternate leaves or branches. This may possibly have belonged to the last named species.

There are also specimens of strobiles, about an inch in length and thickly covered with scales or spore-cases which appear to be in two rows, but this is probably deceptive and an effect of flattening. They very much resemble the strobiles of *Lycopodites Richardsoni* from Perry, but the scales are thicker and more obtuse. This is probably the fruit of some lycopodiaceous plant, and may provisionally be referred to the genus *Lepidostrobus*.

The beds containing these fossils evidently belong to a lower horizon in the Erian than that containing the fossils collected by Mr. Foord.

ON THE GASEOUS SUBSTANCES CONTAINED IN THE SMOKY QUARTZ OF BRANCHVILLE, CONN.

By Arthur W. Wright, Yale College.*

The existence in quartz of numerous cavities containing a liquid substance is a matter of familiar occurrence, and great interest has attached to the investigation of the character of these inclusions. Although the presence of carbon dioxide and water had been well established, the difficulty of separating the contents of the cavities in sufficient quantity has hitherto prevented a direct examination of them. The quartz from Branchville is remarkable for the great size and number of the cavities, the peculiar characteristics of which are described by Mr. Hawes in the preceding article.† The fortunate circumstance, noticed by him, that when exposed to a moderately high temperature it decrepitates and is speedily resolved into small fragments, made it possible to obtain with great ease and convenience enough of the enclosed substances for an extended examination. The material employed was derived from the collection of minerals from Branchville, of Professors Brush and Dana.

The temperature required for the disintegration of the quartz is much below that of red-heat, and the bursting of the solid material is evidently due to the increased tension of the gas, as it does not occur in those fragments which contain no cavities. The first trials were made with glass vessels, but the sharp fragments of the mineral were shot off with such violence as to destroy them immediately. Recourse was therefore had to a porcelain tube about one centimeter in diameter, glazed inside. This was carefully cleaned with pure distilled water, one end stopped with a plug cemented in, and the other provided with a perforated brass cap, into which could be screwed a piece through which passed a slender glass tube, the joint being rendered tight by a thin washer of india-rubber or paper. The closed end of the tube was filled for some 12 centimeters with pieces of clean glass rod,

* Reprinted from the Amer. Journal of Science of March, 1881.

† Dr. Hawes' interesting article is not reproduced here, as it would be incomplete without the illustrations.

and upon these rested a loose plug of calcined asbestus. The quartz, broken into fragments of such a size as to permit their entrance, was dropped into the tube, filling it to within 10 or 12 centimeters of the mouth. When heated in a Bunsen flame, the whole of the material could be brought to the requisite heat without causing any perceptible elevation of the temperature of the cement joints. This receptacle, when charged, was connected by means of the glass tube with a Sprengel pump, all joinings of the glass being made by fusing, and the whole was easily rendered absolutely free from leakage.

The pump having been kept in action until no gas appeared to pass down, heat was cautiously applied to the tube, and gradually increased until a little gas was liberated from the quartz. When this had been thoroughly pumped out, removing thus the last portion of air, the heat was again applied and continued until the cessation of the decrepitation showed that no more gas could be obtained. The mercury was then set running in the pump carrying the gas into the measuring tube used for the analysis. A preliminary examination showed the greater portion of the gas to be carbon dioxide, the remainder apparently consisting chiefly or wholly of nitrogen. A considerable amount of water was also found to be present. In the succeeding operations this was collected for examination by causing the gas as it issued to pass through a U-tube of small caliber which was placed in a freezing mixture. As the temperature of the refrigerating mass was such as to reduce the tension of vapor to less than one millimeter, nearly the whole of the water was thus retained.

For the more careful analyses two portions of the rock were selected representing the greatest differences in the material. The first, No. 1, was of a light gray color, somewhat milky in appearance, and contained many cavities easily visible without the aid of a lens. The weight of the material employed was 21·70 grams, which, divided by the specific gravity 2·63, gives for the volume 8·25 cubic centimeters. The second portion was of the darker variety having a smoky brown color, appearing nearly black in large masses. The gas cavities in this were not so conspicuous, and apparently were less numerous. The amount of the material placed in the tube for examination was 19·49 grams, and the volume 7·41 cubic centimeters. This portion is designated as No. 2 in the following paragraphs. The total quantity of gas collected from No. 1 was 13·61 cubic centimeters,

or 1·65 times the volume of the quartz. From No. 2, 7·20 cubic centimeters of gas were obtained, or 0·97 times the volume of the material employed. From the first portion examined in the preliminary work 1·33 volumes were obtained.

The eudiometer having been transferred to the mercury cistern an absorption pellet moistened with the solution of potassic hydrate was introduced into it, causing a rapid diminution of the volume of the gas. When this operation was complete the residual gas had been reduced to a small bubble in the top of the tube, which could not be measured directly with sufficient accuracy. To find its volume a little of the potash solution or of distilled water was admitted giving a meniscus concave toward the top of the tube. The position of this was carefully noted, and the tube emptied. Mercury was now introduced until the surface of the meniscus occupied exactly the former position of the surface of the water, and the metal was then weighed. The mean of five separate measurements being taken the volume of the gas was thus readily calculated. The results of the determinations with the two different portions of the material gave

I.		II.		Mean.
CO_2	98·34	CO_2	98·32	98·33
N	1·66	N	1·68	1.67
	100·00		100·00	100·00

Cuprous chloride produced no preceptible absorption, showing the absence of carbonic oxide. Potassium pyrogallate introduced into the tube with caustic potash solution produced a slight discoloration of the latter, but no change in the volume of the gas was visible, indicating that oxygen if present was not in recognizable quantity.

To ascertain the presence of hydrogen or other combustible gases a number of tests were made. A spark passed through the gas directly produced no effect, nor upon the addition of oxygen or air alone could any combustion be produced. When the proper quantity of pure electrolytic gas was added the explosion produced no apparent change in the volume. This, if, from the small amount of gaseous substances operated with, it might not safely be concluded that the hydrogen or hydrocarbons were entirely absent, shows that the quantity was exceedingly small. The residual substance then was nitrogen. In these operations, as already mentioned, the gas had passed through a tube placed in a freezing mixture. A later experiment, to be

described in a succeeding paragraph, gave a somewhat different result.

The rock when broken or crushed with a hammer exhales a fugitive but unmistakeable odor of hydrogen sulphide, but the proportion of the gas was too small to be directly detected with the ordinary lead-paper even when directly applied as a cover to a diamond mortar in which a considerable quantity of the material had been powdered. But when a slip of the paper was introduced into a tube filled with the extracted gases, a slight but distinct coloration was produced. The same was true in a somewhat more marked degree with a paper moistened with mercurous nitrate, indicating sulphurous oxide. To test this more fully separate slips of filtering paper were wet with plumbic acetate, sodium nitro-prusside, and mercurous nitrate. When dry they were introduced into a small tube through which gas freshly liberated was made to pass. Snow applied for a few moments to the tube ensured the presence of sufficient water to moisten the paper slightly. The first underwent a slight discoloration, which after a time disappeared, the second assumed a pinkish tint, while the third was distinctly blackened, thus proving the presence of a trace of both the gases in question, a conclusion moreover which was verified by other and independent trials.

As both hydrogen sulphide and sulphurous oxide are absorbed by potasssic hydrate it was important to ascertain whether these gases were in sufficient quantity to affect the conclusion given above as to the amount of carbon dioxide. A portion of the gas collected in a clean tube was therefore submitted to a special examination. A pellet of ferric oxide formed upon the end of a platinum wire produced no effect at all, though kept in the gas for several hours. A similar pellet of manganese dioxide moistened with syrupy phosphoric acid likewise caused no perceptible effect, thus proving that these gases were not present in any measurable quantity.

An approximate estimation of the amount of water was made as follows: The U-tubes in which the water had been condensed were sealed after the gas had been thoroughly pumped out. The temperature of the freezing mixture was from —19° to—20° C., so that the tension of the residual vapor was less than one millimeter, which was confirmed by the reading of the guage of the pump at the end of the operation. The connecting tubes were fused off and the portion containing the water withdrawn. The

amount of liquid thus obtained was considerable. The tubes were carefully weighed, then opened, and after an examination of the liquid, thoroughly dried, and weighed again. The weight of the water in No. 1 was thus found to be 13·4 milligrams, in No. 2, 12 milligrams, corresponding respectively to 13·4 and 12 cubic millimeters at 4°. The volume of the quartz in the first instance being 8·25, and in the second, 7·41 cubic centimeters, we have for the amounts contained in one cubic centimeter of the mineral, 1·63 and 1·62 cubic millimeters respectively, no correction being made for temperature, as the results are only approximate. This would indicate a comparative uniformity in the distribution of the water, while the amount of the gas varies. But such a conclusion is at best doubtful, inasmuch as the darker quartz is not as thoroughly broken up by the heat as the lighter variety, and the refrigeration of the tube No. 1. was not made complete at first, so that some water doubtless escaped with the gas uncondensed.

A small portion of the water removed with a minute pipette was dropped upon red litmus paper, where it produced a strong but fugitive alkaline reaction, implying the presence of free ammonia. This was confirmed by adding Nessler's test solution to the remainder of the liquid in the end of the tube, in which it caused the characteristic yellow coloration, and, in one instance a slight precipitate. Before the tubes were opened it had been noticed that the water, though to all appearance prefectly transparent and colorless, left a white deposit upon the glass where a drop of it had evaporated. When this was heated by the application of a small gas flame, it did not fuse, but appeared to shrink or to diminish in amount very slightly, while the glass around it and over it lost its transparency as if corroded. A similar but very slight action upon the glass where the moist gas had come in contact with it had previsouly been observed. This suggested the presence of fluorine. The glass of the tube in which the effect was most marked contained some lead, but the other showed it also to some extent. A special experiment with a tube free from lead, which had been most carefully cleaned, gave the same result, though in somewhat less markéd degree. Its appearance would be accounted for by the supposition that the water of the cavities contained some hydro-fluo-silicic acid in solution, resulting from the decomposition of silicon fluoride, or, as ammonia was also present, from an ammonium compound of the acid.

As was mentioned in a preceding paragraph, no evidence of the presence of a hydro-carbon compound was discovered in the examination of the gas which had passed slowly through the cooled tubes. The tubes themselves, however, contained what appeared like minute drops of some oily substances, so small as to be scarcely visible without a lens, and quite insufficient for examination. In order to investigate this point more satisfactorily as also to obtain a greater quantity of the residual gas left by absorption of the carbon dioxide, an experiment was made as follows: A bolt-head of porcelain, glazed interiorly, and having a capacity of about 300 cubic centimeters, was employed for the reception of the quartz, of which 196 grams, making 7·54 cubic centimeters, were used. It was arranged that after the air had been pumped out, the gas from the quartz should pass through a strong solution of potassic hydrate contained in a large U-tube, all connections being made with fused glass joints as before. The greater portion of the carbon dioxide was thus absorbed. Unfortunately just at the close of the operation a slight crack in the porcelain vessel admitted some air, but the tube leading to the pump was sealed immediately, so that the amount mixed with the gas was not too great to permit a quantitative examination of the gas to be made. A portion of the latter being transferred to the eudiometer, and just sufficient electrolytic gas being admitted to ensure combustion, the volume of the gas after explosion was found to be considerably increased, with the production of carbon dioxide. Repeated tests gave uniformly the same result, but the expansion was greater at first than after the gas had been kept for two days in the pump. This must be regarded as evidence of the presence of the vapor of some condensable hydrocarbon having a large number of carbon atoms in the molecule.

The quartz on heating entirely loses its color, the coarse powder which is left being almost snow-white. Now, in the experiment just described, a dark brownish deposit was formed in the tube leading from the bolt-head, and the potash solution after the passage of the gas had become brown, the color being almost exactly the same as that of the quartz before the heating. After standing a day or two a small amount of a dark brown, nearly black, substance separated out as a precipitate and the liquid lost it color. The potash solution was now decanted and the dark deposit examined. Treated with alcohol it dissolved but partially,

communicating its color to the liquid, and taking on a tarry consistency. On evaporating the alcohol, the substance was volatilized by more intense heat, with a strong bituminous odor, very much like that given off by cannel coal when burning. The brown deposit in the tube also gave off the same odor when strongly heated. These results imply that the smoky color of the quartz is due to the presence of a hydrocarbon of the nature of bitumen, which is driven off by heat, and the partial decomposition of which, at the high temperature reached, accounts for the heavy hydrocarbon found in the residual gas, or condensed upon the walls of the cooled tubes. These facts, moreover, are entirely in harmony with and confirm the conclusion of Forster* from an examination of the remarkable smoky quartz from the canton of Uri, that the color of the latter is due to the presence of some volatizable hydrocarbon, though they do not directly connect the ammonia with the latter, as his observations appear to do.

After the operation just described had been concluded, some pure distilled water was introduced into the bolt-head, and after standing for some time was then withdrawn. Tested with argentic nitrate it gave a considerable precipitate of argentic chloride, while when examined spectroscopically it afforded satisfactory evidence of the presence of sodium, but of no other metal. The water previously examined was found to be free from both chlorine and sodium. The bolt-head had been scrupulously cleansed before use, and great care was taken in this, as in all the experiments, to prevent contact of the quartz with things that might communicate to it any impurity. This result would indicate that the cubical crystals observed by Mr. Hawes in some of the cavities were chloride of sodium. Search was also made for chlorine or chlorine compounds in the gas. A quantity of this freshly liberated was passed through distilled water. This, on the addition of argentic nitrate, was very slightly clouded, making the existence of a trace of some chlorine compound probable. Not unlikely a minute proportion of ammonium chloride is among the contents of the cavities.

The quantitative relation of the water to the gases obtained from the quartz may be made more evident if calculated for a temperature of 100° C. at which the former would be entirely converted into vapor. Taking the amount of water per cubic

* Pogg. Ann., cxliii, 173, 1871.

centimeter at 1·62 millimeters as found above, this multiplied by 1694·3 gives 2·74 cubic centimeters for the volume of the water vapor at 100°. If we take the gaseous volume for one cubic centimeter of the quartz at 0·97 cubic centimeter, the result derived from No. 2 above, where the water determination was most satisfactory, the temperature of the room at the time of measurement being about 20° C., we have for the volume at 100° neglecting the correction for the barometric pressure which was not greatly different from 760 mm., 1·23 cubic centimeters. Reduced to parts in 100 these volumes give

CO_2	30·48
N	0·50
H_2O	69·02
	100·00

For the reasons mentioned above this must be regarded, so far as the water is concerned, as merely an approximate result.

For the gases alone, leaving out of view the bituminous matter, which is not known to be specially connected with the cavities in the material, and probably is not, we have the following summary:

CO_2	93·33
N	1·67
H_2S	*trace*
SO_2	"
H_3N	"
F	"
Cl ?	"
	100.00

The ammonia, if derived from the gas cavities, undoubtedly existed there in combination with the carbon dioxide, as ammonium carbonate. From the considerations mentioned above the fluorine and chlorine detected by the tests applied also represent compounds of these elements with some of the other substances present. The results of the investigation show that the contents of the cavities are chiefly water and carbon dioxide, with a small portion of nitrogen, thus essentially confirming the conclusions derived from microscopical examination.

NOTE ON THE GEOLOGY OF THE PEACE RIVER REGION.

By G. M. Dawson, D.S., A.R.S.M., F.G.S.

(Abstract of paper read before the Natural History Society, Montreal, Feb. 28th, 1881.)

Till 1875 we may be said to have known absolutely nothing of the geology of the Peace River region. In that year, Mr. Selwyn, the Director of the Geological Survey, starting from McLeod's Lake in British Columbia, descended the Parsnip and Peace Rivers to the confluence of the Smoky River, returning by the same route. The geological notes published in the report of the expedition have constituted the basis of subsequent work. In 1879, it was determined to ascertain more completely the character of the Peace and Pine River passes as railway routes, and the prospective value of the Peace River basin. The author of the paper was a member of the expedition of that year, and the information obtained at this time, with that formerly alluded to, enables a clear general idea of the geological features of the district to be formed. These are of interest as representing the furthest northern portion of the interior continental region yet known with any precision, the country examined lying chiefly between the 54th and 57th parallels of north latitude.

The Rocky Mountain range is here narrow and comparatively low, the higher peaks seldom exceeding 6,000 feet. It is chiefly composed of limestone, in massive beds, in some of which fossils of Devonian age have been found, the most abundant form being *Atrypa reticularis*, a shell widely spread in the Devonian rocks of the Mackenzie district further north. The beds of the mountains have general westerly dips, and overturned folds probably occur. On the east side of the range, on both Peace and Pine Rivers, hard dark calcareous beds are found holding *Monotis subcircularis*, a form characteristic of the "Alpine Trias" of Nevada and California, and found also in several places on the British Columbian coast. To the east of these beds of the mountains, and resting quite unconformably on them, are the Cretaceous rocks, which, between the mountains and eastern outcrop

of the Devonian rocks on the lower Peace, occupy a basin with a width of nearly 350 miles, implying a Cretaceous sea of that width.

The Rocky Mountains have here formed a shore-line in Cretaceous times, and the Cretaceous rocks along their eastern base are almost entirely sandstones and conglomerates, the constituent fragments of which can be traced to the cherts and quartzites accompanying the limestones. The mountains are bordered to the east by foot-hills, in which, on the upper part of Pine River, for a distance of fifteen miles from the older rocks, the Cretaceous sandstones are folded and disturbed. The disturbance, however, gradually diminishes on receding from the mountains, and the beds at length become flat, or are affected by very slight and broad undulations only. Shaly materials increase in importance eastward, and the Cretaceous series eventually resolves itself into the following sub-divisions, which are placed opposite their supposed representatives in the Western States:

Upper, or Wapiti River Sandstones	Fox Hill (and Laramie?)	
Upper, or Smoky River Shales........	Pierre,	Colorado.
Lower, or Dunvegan Sandstones.......	Niobrara,	
Lower, or Fort St. John Shales........	Benton,	

The correlation as above shown is based partly on palæontological evidence, partly on lithological resemblance. The synchronism of the upper shales with the Pierre group is quite definitely proved by the fossils. No fossils have been obtained from the overlying sub-division. The fossils of the Lower Sandstones are peculiar, consisting chiefly of fresh-water and estuarine forms and land plants. In the lower shales the most characteristic fossil is a large *Ammonite* resembling *Ammonites* (*Prionocyclus*) *Woolgari*, but according to Mr. Whiteaves specifically distinct. No beds so low as the Dakota horizon have yet been discovered here, though they may exist.

The lithological resemblance of the shales of the upper and lower sub-divisions to those of the Pierre and Benton groups is exceedingly close. It is conjectured that these mark periods of general submergence, when sediment-bearing currents passed freely through the interior continental valley. In the Dunvegan sandstones we may see an indication of the elevation of land surfaces to the north and west, which interrupted these currents and allowed the contemporaneous deposition of the Calcareous Niobrara beds of the South.

The fossils of the Lower or Dunvegan sandstones are of special interest, giving us a number of fresh-water molluscs and land plants of a stage of the Cretaceous previously almost unrepresented in these respects. The fresh-water molluscs clearly resemble those of the Laramie group, and the plants, while showing a close analogy with those of the Dakota group, help to fill a gap in time between these and those of the Vancouver (Chico) Cretaceous and the Laramie and Fort Union.

In 1872, Prof. Meek described a series of beds at Coalville, Utah,* which appear to have been formed at the edge of the Cretaceous sea at the mouth of a small river, and hold fresh-water molluscs. The fossils from these beds represent a stage somewhat higher in the Cretaceous than those of the Dunvegan rocks, but closely resemble them as well as those of the Laramie series. Meek writes:—"The group of fossils found in the dark indurated clay G is, in several respects, a very interesting one, not only because every species is new to science, and all of them entirely different from any yet found in any other locality, or even in any other beds of this locality (with possibly one or two exceptions), but on account of their modern affinities. Here we have, from beds certainly overlaid by 1000 feet of strata containing Cretaceous types of fossils, a little group of forms presenting such modern affinities that, if placed before any palæontologists unacquainted with the facts, they would be at once referred to the Tertiary."

In the Peace River district we have, instead of a merely local intercalation of this character, a widely extended series of Cretaceous beds persistently holding fresh-water and estuarine types of molluscs and land plants.

The chief evidence of the Tertiary age of the Laramie and Fort Union beds, after that afforded by the plants, has been found in the Tertiary aspects of the molluscs, most of which are fresh- or brackish-water forms. Hitherto little has been known of the fresh-water fauna of the undoubted Cretaceous; but if this should prove to have, as now appears probable, a "Tertiary" aspect throughout, it will tend to break down the molluscan evidence of the Tertiary age of the Laramie, and unite this formation still more closely with the underlying beds.

March 1, 1881.

* U. S. Geol. Survey of Territories, 1872, p. 435.

ON A NEW SPECIES OF PTERICHTHYS, ALLIED TO *BOTHRIOLEPIS ORNATA* EICHWALD, FROM THE DEVONIAN ROCKS OF THE NORTH SIDE OF THE BAIE DES CHALEURS.*

By J. F. Whiteaves.

The nomenclature of some of the Devonian Placoderms of the sub-order Ostracostei of Huxley is still in a state of great confusion. Thus, *Pterichthys* Agassiz and *Bothriolepis* Eichwald, are both quoted by Pander as synonymous in part with *Asterolepis* Eichwald, while the *Asterolepis* of Agassiz and Hugh Miller is regarded by the same authority as synonymous in part with *Homostius* Asmuss, and in part with *Heterostius.* On the other hand, Prof. R. Owen claims †that *Pterichthys* should be retained in preference to *Asterolepis* and *Bothriolepis* Eichwald, on the ground that "no recognizable generic characters were associated" with the latter names ; and, as this view has been very generally accepted by paleontologists, it will be adopted provisionally in these notes.

The only remains of fossil fishes yet recorded as occurring in the Paleozoic rocks of North America which may prove to be referable to the genus *Pterichthys*, are some isolated scales from the Catskill group of Tioga County, Pennsylvania, described by Prof, Hall in 1843 as *Sauripteris Taylori*, but which Dr. Newberry thinks have the characteristic sculpture of *Bothriolepis.* The name *Pterichthys Norwoodensis*, although inadvertently cited by Mr. S. A. Miller, on page 238 of his "American Paleozoic Fossils," should have been rejected long ago, for in the first volume of the Second Series of this Journal, dated 1846, Drs. Norwood and Owen showed that the specimen for which it was suggested is the type of their genus *Macropetalichthys*, and of a species which they described as *M. rapheidolabis.*

In the summer of 1879, Mr. R. W. Ells, M. A., of the Geological Survey of Canada, had the good fortune to find, in a concretionary nodule of argillite from the north side of the Baie des Chaleurs immediately opposite Dalhousie, a mould of the plastron

* Reprinted from the American Journal of Science for August 1880.
† Palæontology, Second Edition, page 141.

or ventral surface of a true *Pterichthys* (as defined by Prof. Owen) with one of the pectoral spines in situ. At the earliest practicable opportunity, Mr. Ells revisited the locality, and in the first week of June last obtained three exquisitely preserved specimens of the buckler of the same species and several fragments, also some isolated scales of a *Glyptolepis*. The finest example of the Canadian *Pterichthys* collected by Mr. Ells had a large piece broken off the left margin when it was found, but with this exception the whole of the upper surface of the helmet and buckler is finely exposed (the plastron being partly covered by the matrix), and the outline of the orbital opening is clearly defined. A few weeks later, Mr. T. C. Weston, also of the Canadian Survey, collected an additional number of fine specimens of the *Pterichthys* from this locality, some of which illustrate admirably the shape, sculpture and mode of articulation of the pectoral spines. Associated with these there are, in Mr. Weston's collection, a nearly perfect but badly distorted specimen of a *Glyptolepis* fully seven inches in length, some fragments of *Psilophyton*, and a spore case of a *Lepidodendron*.

Taken collectively, the specimens thus far obtained of the Canadian *Pterichthys* show nearly all the characters of the helmet, buckler, plastron and pectoral spines, in the most satisfactory manner, but no vestiges of the tail have yet been detected, nor of any of the fins other than the two pectoral spines. The nature of the mouth and of its dentition, if it had any teeth, are unknown, and the small isolated plate in the orbital cavity (the "os dubium," of Pander, the " median" plate of Owen) has not yet been observed. In the number, outlines and disposition of the plates on the upper and lower surface of the head and body, and in the shape and mode of articulation of the pectoral spines, the Canadian fish agrees, in every essential point, with Pander's well known figures of a typical *Pterichthys*, but the sculpture of the entire surface of the former is precisely like that of *Bothriolepis ornata* Eichwald, which is thus described by Agassiz :* " Les ornements de cette espèce consistent en petits enfoncemens circulaires placés les uns à côté des autres et séparés par des carènes qui, par leur juxta-position, paraissent hexagonales à-peu-près comme les vitraux ronds des anciennes fenêtres, avec l'entourage en plomb qui les réunit. Les creux ont à-peu-près la gran-

* Monographie des Poissons Fossiles du Vieux Gres Rouge, &c., p. 99.

deur d'une bonne tête d'épingle, et ils sont placés en séries linéaires plus ou moins régulières, formant des lignes ondulées sur la surface de l'écaille. Pour la plupart, ces creux sont isolés les uns des autres, quelquefois aussi plusieurs se confondent en formant un sillon plus ou moins long. Les carènes intermédiaires sont tranchantes et minces, mais elles se maintiennent au même niveau; l'on ne pourrait donner une meilleure image de cette sculpture des plaques, qu'en enfonçant des épingles, la tête la première, sur le gyps encore frais, car il en résulterait le même dessin. En examinant ces plaques à la loupe, on voit au fond de chaque cellule osseuse un petit trou central, qui mène dans un canal médullaire de l'intérieur de l'écaille. Evidemment ces trous étaient destinés à donner passage aux fins vaisseaux sanguins qui montaient à travers l'écaille pour se ramifier dans l'épiderme qui couvrait la plaque." All the markings so carefully described in the above passage. even to the minute perforations through the plate in the centre of each pit, can be made out with perfect ease in most of the specimens collected by Messrs. Ells and Weston.

The Canadian *Pterichthys* is so closely allied to the *Bothriolepis ornata* that it is by no means certain whether the two are specifically distinct or not. Apart from its peculiar sculpture, the specific characters of of *B. ornata* are very imperfectly ascertained, the species having been founded exclusively on a few large isolated plates of a placoderm, from the Devonian rocks of Russia and Scotland. Until more perfect examples of *B. ornata* shall have been described and figured, it will be impossible to institute an accurate comparison between it and the nearly related Canadian form. There are, however, good reasons for supposing that the European species attained a much larger size than the Canadian, for Agassiz says that the plates of *B. ornata* are from three to six inches in length, and judging by this, the approxmate length of its helmet and buckler together may be roughly estimated at from six to twelve inches at least. The largest isolated plate of the *Pterichthys* from the Baie des Chaleurs yet obtained (one of the ventro-laterals) is only two inches and a half long, while the smallest of two perfect specimens of the united helmet and buckler from the same locality is a little over two inches in length, and the largest (the fine specimen collected by Mr. Ells) is just six inches.

Under the circumstances, the writer thinks it most prudent to give to the Canadian *Pterichthys* a local and provisional name,

with a brief diagnosis of its most salient characters, as follows: premising that a more detailed description of the species, accompanied with figures, will appear at an early daté in one of the publications of the Canadian Geological Survey.

PTERICHTHYS (BOTHRIOLEPIS) CANADENSIS, nov. sp.—Plastron nearly flat. Helmet moderately arched above, most prominent immediately behind the orbital cavity where it rises into a ridge or blunt keel, which is continued, at intervals, with greater or less distinctness, along the median line of the buckler. Buckler slightly arched, median keel strongest in the centre of the dorsomedian plate, and in the posterior half of the post-dorsomedian. General outline of the helmet and buckler combined elliptic-ovate, their united length being nearly, but not quite, twice the maximum breadth of the buckler. Dorsomedian plate large, hexagonal, apparently rather wider than long; its upper margin slightly concave on both sides and somewhat pointed in the middle, its lower margin being concave. Orbital cavity situated nearly in the centre of the helmet, transversly reniform or bean-shaped in outline, much wider than high. Upper margin of the orbital cavity broadly, regularly and very shallowly concave, the lower being correspondingly convex, while the two lateral extremities are symmetrically and rather narrowly rounded.

Pectoral spines extending nearly to the posterior end of the buckler, thin and compressed vertically; moderately broad laterally where they are articulated to the ventro-lateral plate, and widening to about their mid-length, where they exceed the breadth at their articulation by about one line. From the widest point the breadth of the spines is again gradually reduced up to the joint separating the two segments of which they are composed, from whence they taper gradually to an acute point. The two segments are divided, nearly transversely, by a ball and socket joint, the ball being in the anterior and the socket in the posterior or terminal segment. The anterior end of each spine seems also to be furnished with a ball and socket joint, as there is a strongly inflected cavity in the ventro-lateral plate to receive the anterior end of the spine which latter terminates in a rounded protuberance. On the inner and outer lateral margin of the pectorals there is a row of crowded, nearly erect, conical, tooth-like, hollow spines. These are directed towards the articulation of the spine with the ventro-lateral plate up to about the mid-length of the anterior

segment, and from thence they begin to point towards the posterior termination of the spine.

Sculpture of the helmet, buckler, plastron and pectoral spines very closely resembling that of the plates of *Bothriolepis ornata* but much finer and more delicate.

ON SOME REMARKABLE FOSSIL FISHES FROM THE DEVONIAN ROCKS OF SCAUMENAC BAY, P. Q., WITH DESCRIPTIONS OF A NEW GENUS AND THREE NEW SPECIES.

BY J. F. WHITEAVES.

Immediately after the preceding paper was written, Mr. A. H. Foord, of the Geological Survey of Canada, went down to the Baie des Chaleurs and spent two months and a half of the summer of 1880 in a careful and systematic examination of the fish-bearing beds of the Devonian rocks of the north bank of the mouth of the Restigouche river. The exact locality at which the *Pterichthys* and other fossil fishes were found by Messrs. Ells and Weston is not the Baie des Chaleurs proper but Scaumenac Bay, Bonaventure County, Province of Quebec. On the shores of this bay a series of shales, sandstones and conglomerates, now known to be of Devonian age, are overlaid, apparently unconformably, by the red sandstones and conglomerates of the "Bonaventure Formation." The geological structure of both banks of the Restigouche river was examined by Dr. Abraham Gesner in 1842, who also was the first to notice the existence of fossil fishes and plants in the shales and sandstones of Scaumenac Bay. Referring to the latter, Dr. Gesner says, * "In these sandstones and shales I found the remains of fish and a small species of tortoise, with fossil foot prints": the sculptured plates of *Pterichthys* being evidently regarded by the Doctor as portions of the carapace or plastron of a small tortoise.

From these deposits Mr. Foord succeeded in obtaining an extensive and interesting collection of fossil fishes. Of the entire number of specimens collected, fully four-fifths are referable to

* Report on the Geological Survey of New Brunswick, 1843, p. 64.

the genus *Pterichthys*, which, at this locality, seems to be represented by only one species, the *P. Canadensis*. Some of these are nearly perfect and want only the fins proper and the tail, while others are mere isolated plates or detached portions of the pectoral spines. The new material obtained by Mr. Foord shows that the cranial plates of *P. Canadensis* were furnished with curious appendages, which will be described more in detail a little farther on. In addition to these specimens of *Pterichthys*, there are examples of eight or nine species of fossil fishes in the collection, belonging to at least seven genera. The following is a brief description of the cranial appendages of the Canadian *Pterichthys* and of the characters by which most of the other species may be distinguished, including the definition of a supposed new genus.

Pterichthys Canadensis.

One specimen of *P. Canadensis* shews that the species had two labial appendages, or barbels, attached to the front margin of the head, though, unfortunately, the terminal plates of the anterior extremity of this specimen are so much distorted that it is scarcely possible to ascertain to which of them the barbels were attached. These barbels are almost exactly similar in shape to those represented by dotted lines in the ideal representation of the genus *Pterichthys* on Plate 6, fig. 1, of the "Monographie des Poissons Fossiles du Vieux Grès Rouge," which Agassiz claims to have seen in his *P. latus*,—but in *P. Canadensis* the barbels are very close together at their bases.

In two specimens of a *Pterichthys* from the red beds at the summit of the series, both of which are probably referable to *P. Canadensis*, two remarkable, flattened-conical dermal processes are clearly visible on the helmet, one on each side of the orbital cavity. One of these specimens measures four inches in length, exclusive of the tail, of which, as usual, not a vestige remains; and in this individual the dermal processes on the helmet are half an inch long and two lines and a half broad near their base. Posteriorly, each process appears to fit into the angle formed by the junction of the "prelateral" with the "nuchal" and "post lateral" plates of Prof. Owen. Anteriorly, they are each directed obliquely outwards and forwards across the "prelaterals," which they partly cover. They taper gradually from their base to an obtuse point, are ornamented with a sculpture precisely similar to that of all the other plates and are pressed close to the surface of the helmet.

Diplacanthus.

Two specimens, one shewing scales and longitudinally grooved fin spines and the other a large portion of the body, of a small, smooth-scaled *Diplacanthus*, very like the *D. striatus* of Agassiz and possibly identical with that species.

Phaneropleuron curtum, Sp. Nov.

General outline, inclusive of the fins, varying in different specimens from subovate to fusiform: length also varying from a little more than twice to rather more than three times the height. Head small, between one-fourth and one-fifth the entire length, and apparently obtuse in front. Cranial plates minutely pitted or irregularly corrugated. Scales thin, cycloid, imbricating, sculptured on their exposed surfaces with exceedingly fine radiating lines, which are visible only under a lens. Dorsal fin single, very long and large, commencing at a point considerably in advance of the middle, at first not much elevated above the dorsal margin, but increasing rapidly in height towards the tail, with whose upper lobe it ultimately becomes confluent. Maximum height of the dorsal nearly equal to the length of the head. Caudal fin heterocercal: anal and caudal fins both extending as far outwards from the body as the posterior end of the dorsal does, and separated at their bases by a very narrow interval. Anal fin narrow and elongated, ventrals also long and narrow, and separated from the anal by a space considerably wider than that which intervenes between the anal and caudal. Pectorals unknown. Ribs very slender and well ossified: interspinous bones contracted in the middle and gradually expanding at each end.

Of this species four crushed and distorted but otherwise nearly perfect specimens were collected, which want only the ventral and pectoral fins. Many fragments of this fish also were obtained, one of which shews the shape and position of one of the ventrals. The variation in the outline of different individuals and in the proportions which their length bears to their height, is evidently largely due to the distortion to which they have been subjected. The smallest specimens are the least distorted, and in these the length is much greater in proportion than it is in the larger ones. Thus, the smallest individual collected by Mr. Foord is about thirty-four lines long and ten lines high, while the largest is a little more than six inches long and three inches and a quarter high.

As compared with the *Phaneropleuron Andersoni* of Huxley, from the Old Red Sandstone of Dura Den, the only previously known species of the genus, the *P. curtum* appears to differ in its smaller size, and more especially in its much greater height or depth as compared with its length. Judging by the figures in the tenth Decade of the "Memoirs of the Geological Survey of the United Kingdom," the length of *P. Andersoni* is equal to about five and a half times its height, whereas in adult or presumably adult specimens of *P. curtum*, the length does not much exceed twice the height. On a cursory examination the dorsal, caudal and anal fins of the present species appear to be continuous, but a closer scrutiny shews that the bases of the caudal and anal fins are separated by a short space.

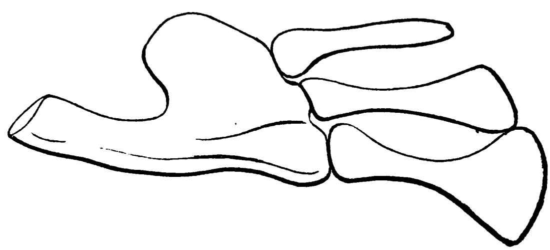
EUSTHENOPTERON,* Gen. Nov.

Generic Characters. Dermal plates of the head densely and irregularly corrugated externally, the corrugations varying in size in different parts of the same plate, but rarely or never coalescing with each other so as to form a complete network. The larger corrugations have a tendency to become tubercular. Teeth, at least the smaller ones, compressed-conical, with a sharp cutting edge on each side. Scales of the body, cycloid, imbricating; their exposed surfaces marked either with minute, close-set, irregular, radiating, tubercular ridges,—or more rarely with a semi-circular area of concentric rows of small, distant, isolated tubercles, upon a surface ornamented with exceedingly fine, wavy, radiating lines. Dorsal fins two, separated by an interval about equal in length to the height of the body between them. Pectoral fins unknown. Ventrals small, short, broad and placed a little behind the first dorsal. Anal fin large and broad, placed opposite to the second dorsal. Caudal fin also large and broad, heterocercal, with an unusually well developed upper lobe.

Vertebral centres not ossified: neural and hæmal spines and inter-spinous bones well developed and completely ossified. Neural and hæmal spines anterior to the second dorsal and anal and for a short distance behind them, blade-like and flattened, with more or less acute margins. Neural spines of the upper lobe of the tail simple, much elongated, subcylindrical and

* From *ευ-σθένης*, stout, and *πτερον*, a fin, in reference to the strongly developed anal and second dorsal.

slightly curved. Fin rays of the lower lobe of the tail supported by nine or ten osselets, each of which is articulated by a transverse joint to one of the modified hæmal spines. On the anterior or lower side of this lobe and nearest to the anal fin, the osselets are very stout and greatly elongated, but they rapidly decrease both in length and size as they approach the posterior termination of the vertebral column. The hæmal spines of the tail, like the osselets, are contracted at or about the middle, and expanded at each end, but the hæmal spines are invariably much shorter than the osselets. All the fin rays, including those of the tail, are composed of a great number of rectangularly divided, short articulations. Fin rays of the second dorsal and anal fin each proceeding from three osselets of unequal size, which are articulated to short prominences, separated by corresponding concave emarginations, in the posterior half of the greatly expanded outer extremity of a broad interspinous apophysis, in the manner shown in the accompanying wood-cut.*



Outline of interspinous apophysis and osselets of the second dorsal fin of *Eusthenopteron Foordi.* Natural size.

EUSTHENOPTERON FOORDI. Sp. Nov.

Specific Characters. Fish large, attaining a length of two feet or more; first dorsal fin very long, narrow and tapering to an acute point behind.

In the sculpture of its cranial plates, in the shape and orna-

---

* In a paper read before the Natural History Society, of which an abstract is given on page 440 of the last volume of this journal, these bones, which were then nearly covered by the matrix, were supposed to be the supports of the ventral fins, in consequence of their general resemblance to the so-called ischium and metatarsals of *Asterolepis*, as figured and described in Hugh Miller's "Footprints of the Creator." Their true nature, however, became at once apparent after a subsequent removal of part of the matrix.

mentation of its scales, and in the fact that the fin rays of its second dorsal and anal fins are both supported by three osselets articulated to a broad interspinous apophysis, this genus somewhat closely resembles the *Tristichopterus* of Sir Philip Egerton. But the vertebral centres of *Tristichopterus* are said to be ossified and the osselets of the lower lobe of the tail are described as "springing from eight or nine interspinous bones," whereas in *Eusthenopteron* the vertebral centres are not ossified and the caudal osselets are articulated to the hæmal spines. Moreover the bony supports of the anal and second dorsal fins are much larger and more fully developed in *Eusthenopteron* than they are in *Tristichopterus*. Thus, in *Eusthenopteron* the length of the osselets of the anal fin is equal to four-fifths of that of the apophysis to which they are attached, and the breadth of the much dilated outer end of the same apophysis is equal to rather more than one-half its length. In *Tristichopterus*, on the other hand, the osselets of the corresponding fin are less than half the length of the apophysis from which they spring, and the slightly expanded outer extremity of the apophysis is not much more than a third of its entire length.

The generic and specific characters of *E. Foordi* have been drawn up from a number of more or less imperfect specimens. The posterior half of the exoskeleton of the species is well seen in a specimen about one foot long, in which, however, the caudal, anal and second dorsal fins are imperfect. The bony supports of these fins and about five inches of the vertebral column are beautifully preserved and well exposed in another specimen. The only parts of the head found so far are fragments of the jaw, with teeth, and some isolated cranial plates, one of which is evidently the operculum.

In associating this species with the name of its discoverer, the writer desires to acknowledge his obligation to Mr. A. H. Foord for valuable assistance in the study of the various specimens described in this paper.

GLYPTOLEPIS MICROLEPIDOTUS, Agassiz. 1844.

One specimen of a small-scaled *Glyptolepis*, which cannot at present be distinguished from the above-mentioned species. The fins of the side of the body exposed to view are well preserved and one of the slender, acutely elongated and lobate pectorals is clearly defined. The shape and sculpture of the cranial plates

are not well shewn and the teeth are not visible. The scales of the body, most of which are either split or broken at the edges, average less than two lines in diameter. Besides the specimen collected by Mr. Foord, another nearly perfect example of the same species was obtained by Mr. Weston in Scaumenac Bay, and both of these have been compared with specimens of *G. microlepidotus* from the Old Red Sandstone of Scotland. The characters of the Canadian and Scotch species certainly appear to be very similar, but the few Scotch specimens accessible to the writer shew only the general shape of the body of the fish and the size and sculpture of its scales, the fins and tail being entirely wanting.

Glyptolepis.

Two split nodules of shale which exhibit on their inner surfaces a number of large detached scales, slender rib bones, an operculum and a fragment of a jaw, with teeth, of a second species of *Glyptolepis*, probably nearly related to the *G. leptopterus* of Agassiz. The scales, which are nearly an inch long, are sculptured with the wavy costæ and semi-lunar or crescentic area of backwardly directed points characteristic of the genus, and the ribs are hollow in the centre. The teeth are short, conical, somewhat compressed and perfectly smooth.

Cheirolepis Canadensis. Sp. Nov.

Maximum length eighteen inches: greatest height less than one-fourth of the length: general outline elongate-fusiform. Head equal to about one-fourth the entire length: cranial plates exquisitely sculptured with delicate, irregular corrugations which are crossed obliquely by minute ribs quite invisible to the naked eye. In some of the cranial plates the corrugations consist of wavy ridges of varying length, separated by corresponding but much wider grooves. Occasionally the ridges appear to be made up of a series of confluent tubercles. In other plates the corrugations or ridges anastomose so as to form a dense but irregular network. Margin of orbital cavity circular. Teeth conical, slender, of unequal size. Scales of the body minute, ganoid, rhomboidal, about one-third of a line long, and sculptured with acute ribs which radiate longitudinally from the posterior angle

of each scale. Scales of the fins and tail rectangular and acutely ribbed at their edges. In the central portions of the fins and tail the scales are twice as long as broad, but near the outer margins of the fins they become much narrower and more elongated. Dorsal fin single, triangular and placed very far backwards: the base of its posterior ray nearly but not quite extending to the commencement of the upper lobe of the tail. Tail heterocercal, its upper lobe fringed by a row of backwardly directed, flattened spines or "fulcral scales," which diminish in length towards the posterior termination of the lobe. Ventral fins situated considerably in advance of the mid-length and separated from the pectorals by a short interval. Anal fin placed much farther forwards than the dorsal and separated from the ventrals by a space slightly exceeding in length the height of the body at the commencement of the anal.

The above name is suggested provisionally for a species of *Cheirolepis*, which resembles the *C. macrocephalus* of McCoy and the *C. Cummingiæ* of Agassiz in the shape and sculpture of the scales of its body and fins. The ventral fins of *C. macrocephalus*, however, are described by McCoy as "nearly central, of moderate size, half their length distant from the anal," whereas the ventrals of *C. Canadensis* are placed much farther forwards and are separated from the anal by a much longer space. The ventrals of *C. macrocephalus*, too, are represented by McCoy as being rather nearer to the anal than they are to the pectorals, but those of *C. Canadensis* are very much nearer to the pectorals than they are to the anal. In *C. Cummingiæ*, according to Hugh Miller, "the large pectorals almost encroach on the ventrals, and the ventrals on the anal fin" but this, as already stated, is by no means the case with *C. Canadensis*. The dorsal fin of *C. Canadensis*, also, is placed much farther backwards than is that of *C. Cummingiæ*, and the anal farther forwards.

Of this species four fine and well preserved specimens were collected by Mr. Foord, two of which are nearly perfect.

Besides those already described, there are two or three species of fossil fishes in Mr. Foord's collection, belonging to different genera, also some isolated teeth and detached bones, whose affinities have not yet been satisfactorily ascertained.

The analogies between the fossil fauna of the fish-bearing beds of Scaumenac Bay and that of the Old Red Sandstone of Scotland and Russia are very striking. The *Pterichthys Canadensis*

is still doubtfully distinct from the *Bothriolepis ornata* of Europe: the fragments of a *Diplacanthus* obtained by Mr. Foord have apparently much the same characters as the *D. striatus* of Agassiz, and the genus *Phaneropleuron* can now be shown to occur in the Devonian rocks of Canada as well as in those of Scotland. *Eusthenopteron* has at least some features in common with *Tristichopterus:* one species of *Glyptolepis* from Scaumenac Bay seems to be identical with the *G. microlepidotus* of Agassiz, from Lethen Bar, while the other bears a general resemblance to the *G. leptopterus* of the same author; and, lastly, the *Cheirolepis Canadensis* here described is certainly closely allied to two Scotch species.

The existence of fossil plants, as well as of fish remains, in the Devonian shales and sandstones of Scaumenac Bay was noticed by Dr. Gesner in 1842, and from these rocks Mr. Foord also obtained a series of specimens of four species of ferns, which will be found described on pages 8–11 of the present number of this journal.

These deposits may have been of fresh water or estuarine origin, for no traces of any marine invertebrata have yet been detected in them, and the fossil fishes which they contain are invariably found associated with land plants.

Montreal, March 14th., 1881.

DESCRIPTION OF A NEW SPECIES OF PSAMMODUS FROM THE CARBONIFEROUS ROCKS OF THE ISLAND OF CAPE BRETON.

By J. F. Whiteaves.

Psammodus Bretonensis, Sp. Nov.

Palatal teeth extremely thin, subrhomboidal, a little longer than broad, the two longest sides nearly parallel and almost straight. Of the two shortest sides one is obliquely and shallowly concave at the margin, with one of the angles rounded off and the other produced into a short beak: while the opposite side is obliquely convex at the margin, with both of its angles rounded. The upper surface of the beaked angle of each tooth is somewhat elevated, and this elevation extends nearly to the centre, the remaining portion being quite flat. To the naked eye this surface appears glossy and polished, but, when examined under a lens, with a good light, it is seen to be faintly and rather distantly punctured. The teeth appear to have been placed in linear rows, in such a way that the convex margin of the short side of one tooth fits into the concave and beaked opposite margin of the next one. Measuring from the centre of the sides, the length of one of the teeth is three lines, and the breadth two lines and a half. The average thickness of the teeth is about a quarter of a line.

Locality: East bank of Scott Brook, nine or ten miles north of St. Peters, Cape Breton Island. Collector: Mr. Hugh Fletcher, B. A., of the Geological Survey of Canada.

The only remains of this species yet obtained are a number of palatal teeth and impressions of palatal teeth, on the surface of a small flat slab of impure limestone. Most of these teeth are detached and isolated, though in one part of the slab there are impressions of four in an unbroken row.

P. Bretonensis appears to be most nearly allied to a *Psammodus* from the Joggins, of which a single tooth is represented by figure 54 (on page 109) of the second edition of the "Acadian Geology," unaccompanied by any description or specific name,—but this figure represents a much larger, thicker and more equilateral tooth than any of those of the present species.

Montreal, March 31st., 1881.

ON THE GLACIAL PHENOMENA OF THE BAY CHALEUR REGION.

BY ROBERT CHALMERS.

[Read before the Natural History Society of New Brunswick, March 1st, 1881.]

The following notes contain a brief summary of the results of observations made by me at intervals during the last seven years on the glaciation and older drift deposits of a portion of the northern section of the Province of New Brunswick.

The area specially examined and to which my observations have been for the most part confined, lies along the southern side of the Bay Chaleur and estuary of the Restigouche, extending from the Nepisiguit river at Bathurst, westward, to the junction of the Metapedia and Restigouche rivers, and is about eighty miles in length following the Intercolonial railway, and from five to ten miles in width southward from the coast line.

To elucidate my remarks on the glacial phenomena of this region I propose, before entering into details, to give a short description of the most prominent physical features of the Bay Chaleur and the country surrounding it, the peculiar conformation of which, assuming it were the same during the glacial epoch as at present, seems to have influenced the ice-sheet which once moved over it, in a marked degree, in producing the exceptional courses of striæ which I am about to describe.

The Bay Chaleur forms part of the northern boundary of the Province, and is about ninety miles in length and fifteen to twenty-five miles in width, stretching longitudinally east and west, and appearing as a broad irregular belt of water, with its sides roughly parallel to each other. Its general trend from the western extremity to its widest part opposite Nepisiguit Bay is about south 60 degrees east; thence to its mouth, which opens into the Gulf of St. Lawrence, its course is nearly north 60 degrees east.* In its physical aspect it may be considered merely an enlarged estuary of the Restigouche, Nepisiguit and other rivers

* All the bearings and courses of striæ given in this paper are referred to the magnetic meridian, the variation of the compass being about 24 degrees west.

flowing into it, and is really nothing more than a shallow valley of erosion, the softer Lower Carboniferous rocks which once probably occupied nearly the entire area of the depression having been, to a large extent, removed by denudation. Its waters are comparatively shallow, the deepest parts being rather nearer the northern coast throughout its whole length. Commencing at the western end, we find the soundings in six different places between that and Point Miscou to be as follows:—At the mouth of the Restigouche, ten fathoms; north of Heron Island, twelve to fourteen fathoms; between Belledune and Black Cape, sixteen to nineteen fathoms; across from Nepisiguit Bay to Bonaventure Point, twenty-six to thirty fathoms; between Grand Anse and Paspebiac, forty to forty-six fathoms; and between Point Miscou and Point Maquereau, which is really the mouth of the Bay, forty-five to fifty fathoms; while beyond its mouth, just south of Bonaventure Island, the depth is about sixty fathoms. It thus appears that there is a gradual descent in the contour lines of its bottom from the mouth of the Restigouche eastward and northeastward into the Gulf, for beyond the Orphan Bank (a small shallow area lying opposite its mouth) the lead goes down, according to the charts, to a depth of seventy-five fathoms or more. It will be seen in the sequel how the slope and configuration of this depression have controlled the course of the ice-sheet whose markings are found on the rocks along its southern shores.

This beautiful expanse of water is without rock or shoal, and has only one solitary isle—Heron Island—lying off the coast of Restigouche County.

The estuary of the Restigouche is a sheltered lake-like sheet of water lying nearly east and west, about twenty-one miles in length, reaching from Dalhousie to Tide Head, six miles above Campbellton, and having an average width of two to three miles. It is enclosed by hills varying in height from 500 to 1000 feet.

The general appearance of the country on either side of the Bay Chaleur is quite different. In the Gaspé peninsula the Shickshock mountains and some minor ridges give to that region an elevated and rugged character, although to the south of these mountains a great portion of the surface resembles a plateau intersected by numerous deep river gorges and ravines. This is especially the case with the district lying between the Metapedia and Cascapedia rivers which is elevated to a height of nearly 1000

feet above sea level, and presents a bold escarpment or mountain flank towards the estuary of the Restigouche and the Bay Chaleur. Lower margins, however, fringe the coast at intervals. At Nouvelle and Tracadiegash this plateau juts into the Bay and rises into lofty peaks (Nouvelle Mountain, 1058 feet, Tracadiegash Mountain, 1865 feet high). East of the indendation known as Cascapedia Bay the coast region, although not so high as that just described, nevertheless maintains to a certain extent the aspect of an undulating elevated district, exhibiting steep banks and cliffs in many places, with an ascending surface behind which merges into the hill ranges that form the axis of the peninsula.

A portion of this mountainous region crosses to the south side of the Restigouche at Dalhousie, rising into a series of narrow parallel hill ranges, composed chiefly of trap, which occupy a width of three or four miles on the south side of the estuary, and run nearly east and west or parallel to the river, varying in height from 500 to 1000 feet, with intervening longitudinal valleys. All these valleys, including that of the Restigouche, are evidently of pre-glacial origin. These hill ranges extend, with some interruptions, south-west, increasing in breadth and height to the Upsalquitch (a tributary of the Restigouche on the south side, thirty-five miles distant from Dalhousie), where they merge into the highland area in the north-west of the Province. Near the junction of these two rivers the twin peaks, Squaw's Cap and Slate Mountain may be seen, reaching elevations of more than 2000 feet above the sea. Along the Upsalquitch, which descends to the Restigouche in nearly a north-west course, and is about forty-five miles long, the general level is elevated from 500 to 700 feet, while several portions of the district rise much higher. Prof. Hind, in his "Preliminary Report on the Geology of New Brunswick" (1864), gives the altitudes of several peaks to the east of that river, among them the Blue Mountains, a ridge near the source of Jacquet river, all of which are from 1000 to 1400 feet above the sea. Not far from the head waters of the Upsalquitch are the central highlands of the Province, where several mountains loom up to heights of 2200 feet, and within the limits of which some of our principal rivers have their sources.

Between this Upsalquitch district and the Bay Chaleur lies an area extending from the Dalhousie hills, on the west, to the

Nepisiguit river or great Carboniferous plain, on the east, which exhibits, in general, a uniform or gently undulating aspect, and is without any eminences, except the Blue Mountains already spoken of and one or two lesser ridges. This area has a gradual descent from the sources of the rivers debouching into the Bay (which vary in length from fifteen to forty-five miles) towards the low shores of that sheet of water. The rocks underlying it have evidently undergone great denudation, especially near the coast; for, although much disturbed—the strata in many places being upturned vertically—they nevertheless exhibit a comparatively even surface.

To the south-east of the Bay Chaleur stretches the great Carboniferous area of the Province. It is a flat district, whose surface as far south as the Bay of Fundy does not attain a greater height than 250 to 275 feet and slopes very gently down beneath the waters of the Gulf of St. Lawrence.

Bearing in mind the topographical features of this region, we can now mark their influence on the course of the glacier which once occupied the depression of the Bay Chaleur and overspread the district to the south of it.

GLACIAL STRIÆ.

Three sets of striæ occur in the region embraced in my observations. I will note some of the most accessible localities where they are to be seen. No two of these sets have been noticed in any one area.

The first set of striæ was observed in the Restigouche valley and on the hills to the south of it, as well as eastward along the Bay shore as far as Jacquet river, extending over a district about forty miles in length. The particular localities where exposures occur are as follows:

(1) At Campbellton, on the west side of a trap hill or *roche moutonnée* at the Intercolonial railway snow-shed. This hill stands about fifty feet above the level of the river, and is rounded and polished on the west side, having a crag-and-tail form.

(2) At the school-house in the village a similar mass of rock is striated and polished on the west side, and broken off on the east.

(3) On the road to Parker's lake, three miles south-west of Campbellton, near the summit of one of the parallel ranges of

hills already referred to, scratches were seen on the north side of the crest of the ridge, about 500 feet above sea level, by aneroid. The exposure shows that the abrading mass ground off the corners of the rocks on the west side.

(4) On Lily lake road, about three miles south of Campbellton, on the third range of hills from the Restigouche river, striæ were observed in several places, about 650 feet above the sea. The rock-masses here also exhibit stossing on the west side.

(5) Near the Intercolonial railway at Charlo river the surface of a trap dyke was seen to be eroded and polished on the west side, but no distinct scratches appeared. Its height was about twenty-five feet above the Bay.

In all these localities the course of the striæ is nearly east and west by the compass.

At New Mills, Benjamin river and Black Point, I noticed *roches moutonnées* in the fields and ledges of crystalline rocks along the shore with their surfaces smoothed and rounded, and the west sides stossed, while the east were broken off and abrupt. Grooves, not very distinct, were observed having a course nearly east and west, or between that and south 70° east at various heights from sea level to fifty feet or more above it.

On the east side of Jacquet river I saw very distinct striæ on the site of the Intercolonial railway, in 1873, in the bottom of a clay cutting, on red conglomerate rock, which is now covered by the track. The course was about east and west, and the height of the ledge above sea level twenty-five feet.

The second set of striæ is met with in the tract lying between Belledune river and Petite Roche, the grooves and scratches being well exposed along the Intercolonial railway. Owing to the harder nature of the rocks in this locality, which are chiefly limestones, traps and diorites, they have resisted disintegrating agencies more effectually than elsewhere within this region, and a large extent of rock-surface is laid bare or but very thinly covered with soil; nevertheless the striæ have been preserved with remarkable distinctness. They are to be seen at distances of every two or three hundred yards in the fifteen miles which intervene between the two places above named. The course is almost invariably south 60° east. These striated rocks are all stossed on the west side. The scratches occur at heights of from 75 to 200 and 250 feet above tide level. Crossing them at a small angle, fainter striæ were occasionally noticed, as if caused

by ice-sheets sliding more directly down the slope into the Bay depression at a later date.

The third set of striæ occurs in the district intervening between Petite Roche and Bathurst, which is about ten miles in length.

(1) A mile east of Petite Roche station along the Intercolonial railway, scratches appear on slate rocks, with a course of about north 65° east. The ledge is probably sixty feet above sea level, and is rounded on the south-west slope.

(2) At Mill Stream (north side), six miles from Bathurst, grits and shales on the site of the railway are distinctly grooved, the direction of the striæ being north 65° east. The grooves occur on a nearly level surface of rock, but afford evidence that the ice-mass moved north-eastward.

(3) On Knight's farm, three miles north of Bathurst, an interesting group of striated surfaces was discovered about a hundred yards east of where the railway crosses it. The rocks are trap, felsite and conglomerate, and stand up a few feet above the general level in the form of bosses or low rounded hills. Their south-western sides are all ground off and polished. No fine striæ appeared, but I noticed a number of wide parallel grooves or furrows which had nearly a north-east and south-west course. Eight or ten of these rock-masses may be seen here planed and grooved in the manner described, the stossing invariably on the south-western slopes, while their north-eastern faces are rough and have a broken-off appearance. It was from an examination of these furrowed rock-surfaces that I was first led to the conclusion that the direction of the ice-flow in the district where the third set of striæ occurs must have been from south-west to north-east.

On rocks a few hundred yards to the north of these, however, I saw what might be taken as indications of glacial erosion on the north-western slopes of one or two exposures. No striæ or grooves were observed, but merely a rounding of the faces; and it was difficult to say whether this was the effect of atmospheric agencies or of ice. If these markings are due to the latter cause, they would indicate that a glacier must have moved over this region in a south-easterly direction at an earlier date than the one whose striæ I have noted.

The elevation of the surface in this vicinity is about 100 feet above the sea.

(4) At Peter's river, on the road to Mill Settlement, striæ appear on slates with a north-east and south-west trend.

(5) Fine clear-cut striæ are seen on granite ledges at Bathurst, in two or more places on the west side of the harbor or basin, the direction being nearly north-east and south-west. The ledges lie below high-water mark, and their glaciation indicates that the movement of the eroding agent was north-eastward.

Whether any one of these three sets of striæ was of an earlier date than the others is a question which it was difficult to determine, as they are closely similar in most respects. But the north-east and south-west scratches in two localities, namely, at Bathurst and Mill Stream, seem to be somewhat finer and lighter than those observed elsewhere.

"TILL" OR BOULDER-CLAY AND ERRATICS.

The "till" or boulder-clay is exposed only in a few localities in the district under examination. Either it is very thinly distributed and lies concealed beneath the later deposits, or it is entirely wanting in a great portion of the region to which my remarks relate, in consequence probably of the extensive denudation which it has undergone. It is met with in the Restigouche valley, however; also on the coast of the Bay at Nash's Creek, and along the Nepisiguit river, near Bathurst. An interesting group of surface deposits, one member of which may, perhaps, be till, was disclosed by a series of borings, six in number, made for foundations to the Intercolonial railway bridge which crosses the Restigouche near the mouth of the Metapedia. Through the kindness of Mr. L. G. Bell, C. E., I obtained a diagrammatic section of these borings just after the work had been finished in 1873, which shows, in descending order, the following formations as described by him:

Sandy soil (at one boring on left bank).....	8 feet.
Strong coarse gravel (probably fluviatile)...	12 to 15 "
Stiff sandy blue clay ("till"?)............	60 "
Sand in some places, black clay in others, resting on the rock..................	5 "
Total thickness................	88

These deposits occupy a valley 400 to 600 yards wide, on either side of which hills rise to the height of 500 feet or more above the river. The depth of the water in the Restigouche when the borings were made, was ten feet, and the height of its

surface above the level of high tide in the Bay Chaleur, eighteen feet. Hence fully seventy-five feet in thickness of this mass of drift, including the whole depth of the "stiff sandy blue clay" and its underlying sands and clays lies below the level of the sea.

Stratified clays holding marine fossils appear to overlie the series just described on the north side behind the "Club House," attaining a height of fifty-five feet above the river, and these, in turn, are overlain by fine sand and gravel to a thickness of fifteen to twenty feet; but nothing like true till appears here.

I am without information as to whether boulders or fossil shells were found in the "stiff sandy blue clay" of this group of deposits when the borings were made, and its origin and relation to the later beds are therefore uncertain. If we suppose it to be stratified clay (Leda clay) then we would have to admit that a marine deposit upwards of 100 feet in thickness was formed here, thirty miles above the river's mouth, where the Restigouche is not more than 500 to 600 yards wide. This would occur too at a time when the hills on both sides would be some hundreds of feet above the sea; for even at the period of greatest subsidence in the Post-Pliocene epoch they must have reared their summits high above the waters which occupied the valley. I can therefore hardly imagine a bed of this kind, of such a depth, being deposited here under these conditions, more especially as the stratified marine clays of other localities in the Bay Chaleur region, so far as observed, are comparatively thin. Further, this "blue clay" and underlying deposits evidently occupy a rock-basin or trough in this part of the Restigouche valley; for borings made across the river's bed at Campbellton, thirteen miles further down, revealed the fact that the rock-surface there is not more than twenty-five to thirty feet below tide level. From these and other considerations, I lean to the opinion that the deposit referred to, or at least a portion of it (for, perhaps its characteristics and exact position were not noted very accurately) may be "till," and that it is probably the *ground-moraine* of the ice-sheet filling a hollow at the junction of the Metapedia and Restigouche rivers, and resting on the pre-glacial river sands and mud. Additional details regarding these beds will be given, however, when I come to treat of the later surface deposits of the district.

The "till" is found in the river's bank, east of Campbellton village, having a thickness of thirty feet above tide level, and

is overlain by stratified fossiliferous clay. At Nash's Creek it likewise appears in a bank on the Bay shore, attaining a height of sixty feet or more where the Intercolonial railway intersects it. In both of these localities it consists of a stiff clay containing a good many boulders, a few of which are scratched. The largest proportion of them have evidently been transported from the west. For example, at Campbellton, considerable quantities of boulders of a peculiar sort of felsite were distributed in the "till," which had been brought from rocks from half a mile to one and a half miles distant to the west. At Nash's Creek boulders of a certain kind of red conglomerate and of trap were met with, which seemed to have been carried distances of from three to six miles in the same direction.

The till at the Nepisiguit river occurs on its left bank and is best seen in a cutting of the Intercolonial railway which is about seventy-five feet above the sea. Dr. Honeyman, who visited this spot, refers to it in one of his papers, entitled: "A month among the geological formations of New Brunswick." Here its color and composition are much different from those of the Restigouche clays, being of a reddish tint, which is derived from the subjacent Lower Carboniferous sandstones, and it is more arenaceous and not so compact.

The "till," as observed at Campbellton and Nash's Creek, seems to have been thrown down in the lee of low hills, occurring at the former place to the east of the elevation immediately behind the village. At Nash's Creek it lies on the coast behind a low swell of limestone and other rocks to the west.

Evidences of the general eastward movement of the ice-sheet are also abundant, from the transport of loose boulders or erratics strewn on the surface in many places within this region. In the majority of cases these appear to be derived from rocks *in situ* a few miles to the west of where they are found. At Petite Roche and Nigadoo river I saw numerous large blocks of limestone and greenstone (diorite) which had their parent beds at Elm Tree river, three or four miles distant. The drift, including boulders, at Little Belledune also appears to have been carried in a similar direction from a patch of Lower Carboniferous sandstones, the red-colored debris overlying the limestones and other rocks to the east of these. Between Nigadoo and Bathurst, however, the district is strewn with the fragments of rocks, the largest proportion of which occur *in situ* in the vicinity.

Erratics are met with occasionally here and there in this region whose presence I am unable to account for without bringing in the agency of floating ice. One of these may be seen in a gorge four miles south-east of Campbellton, through which flows a stream following the Tobique road. It is a grey conglomerate about eight feet in diameter, closely similar to rocks which occupy the valley of the Restigouche to the east. It lies sixty or seventy feet above sea level, and must have been transported thither by floating ice which moved up stream. At Knight's farm, near Bathurst, already mentioned, a few erratics are met with also resembling rocks in Restigouche County; and like instances of the transport of large blocks occur at other localities, indicating that other carrying agents were in operation besides the glacier whose striæ have been observed. It is probable that these latter have been borne to their present sites by icebergs after the ice-sheet had disappeared; and their deposition may have been contemporaneous with that of the stratified marine clay (Leda clay) of the region. The subsequent denudation which the Post-Pliocene deposits underwent has left them exposed on the surface.

From a study of all the facts obtained up to the present date in reference to the drift striæ and till of this region I have come to the conclusion that the mass or masses of ice which moved over it and scored the rocks in the manner described must have been of considerable magnitude. The first set of striæ, if produced by one body of ice, as seems probable, shows that the sheet has been at least six or seven miles wide near Campbellton, filling the valley of the Restigouche to a depth of several hundred feet and mantling the hills to the south of it. East of the Dalhousie hills its width would increase, and must have been very much greater. It probably stretched over the greater part of the Eel river and Charlo river district, which lies immediately south of these hills. At Heron Island it could not have been less than fifteen to twenty miles in width, occupying the whole depression of the Bay here and covering a portion of the district to the south, increasing in extent laterally and probably lessening in thickness towards the east.

The second set, that is, the striæ occurring between Belledune and Petite Roche, afford indubitable evidence, from their regularity of direction, the close parallelism of the scratches and their position on an even sloping surface, that the portion of the

ice-sheet which produced them was one solid mass, and could not have been less than seven or eight miles wide, coveting the area in question. The main body of ice of which it formed a part must have exceeded twenty-five miles in width here, and was probably not less than 300 to 350 feet deep in the middle of the Bay Chaleur depression. The glacier in this part of its course has evidently followed the general trend of that depression, moving about south 60 degrees east. The portion of the ice-sheet which covered the Belledune and Petite Roche districts, therefore, has probably been only the lateral part near the southern border of the general mass, and may not have been more than fifty to one hundred feet thick, perhaps less, thinning out on the ascending surface of land.

The striæ of the third set, although varying in direction from north 45 degrees east to north 65 degrees east have most probably been produced also by the southernmost portion of the main ice-sheet overspreading the district in which they occur. This part of the glacier would likewise be controlled in its movement by the general mass, which from Nepisiguit Bay would trend away nearly in a north-easterly course towards the mouth of the Bay Chaleur. The close parallelism existing between the courses of the striæ in this set with the general direction of that portion of the Bay to the north-east of Bathurst, which is about north 60 degrees east, together with the fact that the glaciated rock-masses are all stossed on their south-western faces, point to this conclusion. Smaller local glaciers may have occupied the slopes of land, as well as the valleys of the larger rivers near Bathurst, however, after the main sheet had taken its departure.

Summing up the data regarding the glaciation of the whole area under review, and noting the correspondence of the striæ in all three sets with the general direction of the Bay Chaleur, and especially with the trends of its northern coast, near which its waters are deepest, I think it may reasonably be inferred that the phenomena of striation and deposition of the till and other drift material are due to one and the same ice-sheet occupying the valley of the Restigouche and the Bay Chaleur depression and extending some distance laterally over the region to the south. This sheet, moving eastward from the highlands of the Restigouche and Metapedia, would follow the sinuosities of these depressions and influence or control those portions of its mass which overlay the sloping land along its southern margin, thus

causing the somewhat anomalous courses of striæ which I have described.

Admitting, then, that the contour of the Bay Chaleur and contiguous country was the same or nearly so in the Post-Pliocene epoch as at the present day, and that the region was covered with a glacier sufficiently large to produce the effects I have indicated, we might next enquire what the approximate extent and thickness of such an ice-sheet were. A glacial mass such as I have supposed covered the area in question must have had its source in the elevated region in the north-west of New Brunswick, and probably also in the Shickshock Mountains near the head waters of the Metapedia. In its eastward descent it would follow the courses of that river and of the Restigouche, which unite thirty miles above the mouth of the latter. From their junction eastward to the Bay its movements would be controlled by the Restigouche valley. Its length, therefore, would not be less than 125 to 150 miles, and may have been much greater; its width after leaving the Restigouche hills would be twenty-five to fifty miles or more; and its thickness in the Restigouche valley not less than 1000 feet; between the Dalhousie hills and Heron Island 500 to 600 feet, and Between Bathurst and Bonaventure probably 300 to 350 feet. In these statements I have given what I consider the lowest estimate of its dimensions, but it is almost certain that they exceeded this very considerably.

This extensive *mer de glace* was evidently an independent body, guided in its flow by the configuration of the surface of the region; and as it advanced eastward its different parts converged or were deflected towards the lowest area, namely, that which now forms the mouth of the Bay Chaleur.

Further, I infer that the glacier was a local one, and not part of a continental ice-sheet, for the following reasons:

1. From its easterly and north-easterly course, as shown by the striæ in the Restigouche valley and at Bathurst, thus diverging from the normal movements of glaciers as evidenced by their markings on the eastern coast of America.

2. From the close parallelism between the courses of the striæ and the trends and sinuosities of the Restigouche estuary and Bay Chaleur, showing that the ice-sheet must have been one of no very great thickness and with an independent movement, to be thus controlled by the contour of the region; and

3. From the fact that such portions of it as overlay the district to the south of the Bay moved down the sloping surface into the depressed area towards the north-east, and near Bathurst followed the courses of the larger rivers debouching into the Bay, instead of pursuing a course to the south-east over the low lying Carboniferous plain. If the Bay Chaleur glacier had formed part of a continental ice-mass, the difference in level between these two areas was not so great as to prevent it from continuing on in a south-easterly course.

Sand and Gravel Ridges or Kames.

(Syrtensian deposits of Matthew.)

I shall now attempt a brief description of a group of sand and gravel beds which occurs near the coast of the Bay Chaleur in Restigouche County, and which, according to the latest theories regarding their formation, seem properly to come under the head of glacial phenomena. The origin and distribution of similar deposits in other places have been ascribed to the agency of marine currents, but in the locality to which I refer it does not seem possible, for various reasons, thus to account for them. This will become apparent as their position and structure come to be examined. In some of their features these Restigouche sands and gravels bear a resemblance to the "till" of the neighborhood, but in other respects, especially in the nature of their materials and mode of occurrence, they afford evidence of being the result of the action of strong, irregular, intermittent currents, which have flowed from the highland area to the west. It also appears probable that they were deposited at the time the ice-sheet which covered the region was melting and breaking up, and owe their formation to the vast floods which swept large quantities of debris from the Restigouche hills to the plain below during that period.

In the district referred to only one of these ridges or kames has yet been traced out and studied to any extent. It lies between Charlo river and Nash's Creek, being about eleven miles in length, and exhibiting the appearance of a winding, irregular ridge or series of mounds whose general direction is nearly parallel to the coast-line and not very far different from that of the glacial striæ in the same locality. It has a width of from two hundred yards to a quarter of a mile or upwards, and does not

rise to a greater height above the level of the district than twenty-five feet, nor more than eighty feet above sea-level, sloping away on both sides, the one facing the Bay being generally the steepest. Where it is widest it encloses hollows; one of these hollows or pits near New Mills is about fifty yards in diameter, and twenty feet or more in depth, although partially filled with later deposits. This kame is intersected by streams and rivers in several places and by the coast-line at Dickie's Cove near Black Point, forming bluffs on each side of that small indentation. Cuttings along the Intercolonial railway have likewise been made through it at various points, showing that the materials of which it is composed are usually sand, gravel and pebbles, more or less stratified, in which are distributed a few boulders from six inches to two and three feet in diameter, nearly all water-worn and well-rounded. These boulders are scattered irregularly through the mass, and many of them resemble, in mineral character, rocks in the hilly district bordering on the Restigouche, consisting chiefly of trap, diorite, felsite, limestone and slate. Several, of a red silicious felsite, were observed closely similar to rocks of that kind occurring in the hills near the railway tunnel at Flatlands, about thirty-five miles distant. Near the bottom portion of the kame at Black Point, however, I saw boulders which seemed to have their parent bed within a distance of three miles to the west. Occasionally erratics of four and five feet dimensions are met with in its upper parts, but they are not common. Irregular strata of fine sand, and sometimes clay, alternate with others of coarser material or are intercalated in them. Instances likewise occur of curved bedding and cross sections generally exhibit a sort of arched stratification. The coarser portions reveal scarcely any traces of stratification, and, as already stated, resemble in some measure the "till," except that the stones are more water-worn and without striæ.

The dimensions of this kame must have been much greater immediately after its formation than now. The streams which intersect it have carried away large quantities of its mass; and its seaward face has been modified to a considerable extent by the action of the waves when it formed a beach, or was in the tideway at the close of the deposition of the stratified marine sands (Saxicava sands). This last deposit, together with the fossiliferous clays next underlying it, both of which are seen resting on the slopes of the kame, especially on its southward

side and along the banks of the rivers where they intersect it, have also changed its outward form in no small degree. The best section of these beds is exposed at Black Point near Dickie's Inn. In the railway cutting at this place the three members of the modified drift occur in superposition. Here and at the shore their thickness in descending order is seen to be as follows:—

Stratified sand (Saxicava) passing into surface gravel....................................	10 feet "
Stratified marine clay holding fossils (Leda)	5 to 10 "
Sand and gravel beds or kame..............	50 feet or more.

These kame deposits have not been observed in contact with the "till"; but between New Mills and Black Point they rest on glaciated rock-surfaces.

I have already referred to the theory of the origin of kames, which supposes them to be due to the effect of oceanic currents, sorting out and redistributing the "till" and morainic debris thrown down by glaciers, and have stated that this theory will not suffice to explain the formation of the kame deposits in question. In straits and along the Atlantic border where the coast is exposed to the sweep of the arctic and other currents these agencies have no doubt had powerful influence in modifying the older drift deposits when the land stood at a lower level. But the position of the Bay Chaleur region, with a highland area to the west and south-west, forbids the supposition that currents from the north-east traversed it. Although we have no data to show what the height of the land was during the formation of these sand and gravel beds; yet in the period subsequent, namely, that of the deposition of the stratified marine clays (Leda clay), which in this district have not been observed at a greater height than 100 to 150 feet above the sea. we find that a subsidence of 400 to 450 feet below the present level would be sufficient to account for the presence of its marine fauna, that is, allowing the bathymetrical range of the species found fossil here was the same as that of similar species existing in the Gulf of St. Lawrence at the present day. Hence, it is quite probable this region was not further submerged during the Post-Pliocene epoch. A sinking of the land to the depth of 450 to 500 feet, however, would not admit of currents flowing up the Restigouche valley, nor over the area in the north-west of the Province; nor does it seem possible that local marine currents which might have circulated within the Bay during Post Pliocene

times could have sufficient strength or velocity to produce these ridges.

For these reasons, as also from the fact that no fossil remains have yet been found in these beds, the theory of marine currents does not appear to be applicable to the solution of the problems presented by the kame deposits in this region.

But, apart from these considerations, no evidence has been obtained in the course of my investigations to show that currents having any power or velocity traversed any part of the area under examination in a south-westerly direction, if we except the transport of a few of the larger erratics which may have been carried about by floating ice. On the contrary, all the data hitherto collected point to the fact of currents moving in an opsite course. The stossing of the hills and exposed rock-masses on their western sides; the direction in which the boulders met with in the sand and gravel series seem to have been transported; the position of the "till" in the lee of elevations; the denuded condition of the region generally as regards surface deposits; the crag-and-tail phenomena exhibited in the case of isolated ridges and peaks, notably at Sugar Loaf Mountain near Campbellton, which has its west end worn bare and steep down to the level of the valley, while at its eastern end a "tail" stretches away several hundred yards, the crest of which stands 300 or 400 feet above tide level—all go to demonstrate that the great denuding and transporting agents proceeded from the west.

On an examination, therefore, of all the facts at hand relating to the position, the materials and the mode of occurrence of the kame described, it appears to me that the theory which explains the origin of similar groups of deposits from the action of glacial rivers or floods during the dissolution of the ice-sheet will account for the phenomena in question more readily than any other. It is a mooted question yet, however, whether these glacial rivers flowed in channels under the ice, or on its surface, although several geologists of note have quite recently adopted the hypothesis of their being super-glacial. They are supposed by these geologists to have formed channels on the surface of the ice-sheet, carrying *detritus* from higher levels and depositing it at their mouths in a partially stratified condition as the glacier melted and withdrew. Rivers analogous to these are said to have been observed on existing glaciers in the arctic regions during the summer months.

But whatever explanation be finally accepted, it is at least probable, with regard to the Restigouche sands and gravels, that their deposition took place when the ice-sheet which occupied the Bay Chaleur depression was breaking up and retreating to the hills. The river torrents which would then pour down the Restigouche valley and from the adjacent snow-and-ice-clad summits must have been enormous. Moreover, the physical conformation of this valley and adjacent district favors the supposition that a portion of the flood which emerged from it would find an opening to the level country below by the Eel river pass, a gap or break in the Dalhousie hills, through which the Intercolonial railway now runs. A glacial river or flood following such a course would be very likely to deposit its burden of sand, gravel and stones where we now find the kame referred to. The winding, irregular formation of this kame is proof that the materials of which it is composed were not moved and arranged by regular, steady currents, but rather were brought to their present position by rapidly-flowing waters, such as we might suppose would sweep down from the hills among the dissolving remnants of the ice-sheet. The enclosed hollows favor the same view. The large boulders in its upper portions have probably been carried thither by icebergs at a subsequent period, when the whole kame was beneath the waters of the Bay.

If we admit that this kame is the result of the transport of detrital material by a super-glacial river, then at the time of this flood the Restigouche valley and estuary must have been occupied by a dissolving ice-sheet probably 200 or 300 feet thick. From the configuration of the estuary, which resembles a lake-basin with an outlet opening towards the south-east, this body of ice would, when its surface fell below the level of the enclosing hills, be unable to move out of this depression, and would, consequently. thin down and melt almost wholly in the situation in which it lay, or with but very little eastward motion. Eel river pass, now only forty to fifty feet above sea level and filled with stratified marine deposits, would then likewise be occupied with a portion of the same mass of ice extending eastward probably as far as Heron Island. On the surface of this ice-sheet would be thrown the debris brought down from the hills, as well as the earth and stones exposed in the thawing of the glacier itself. This detrital material must have accumulated in large quantities. The strong currents supposed to flow over the ice

surface from higher levels every summer would be sufficient to transport this *detritus*, which included coarse gravel pebbles and small boulders, to the terminal ice-front.

There are certain masses of clay, sand and gravel incorporated in this kame, however, without stratification. These have probably been dropped down *en masse* from the melting ice-sheet without undergoing the sorting action of the currents.

What the height of the land was at this period I have had, as already intimated, no means of ascertaining. At the time the Bay Chaleur glacier had attained its maximum thickness and extent the region probably stood somewhat above the present level. For, it it is difficult to imagine the moving ice-sheet clinging so closely to its bed and following the different courses of the Bay Chaleur valley, if the sea then stood at its present height, or was above it relative to the land. As the melting of the glacier is supposed to have taken place during the period of subsidence, the region was therefore slowly sinking beneath the waters of the Bay when the deposition of the sand and gravel beds occurred, and probably was not very far from the level at which it now is.

Some facts obtained in the course of my examination of this district would lead me to infer that the oscillations of level which the Bay Chaleur region underwent in the Post-Pliocene epoch have not been so great as appear to have taken place in the St. Lawrence valley. Among them, I may mention the position of the stratified marine clays and sands (Leda clay and Saxicava sand), which, as already stated, have not been observed at greater heights than 100 to 150 feet; and the preservation of the ice-markings on exposed rocks and ledges above that level in places where we might expect them to have been obliterated, had the sea covered them and subjected the rocky slopes to the action of the waves and coast ice. But further observation on this point is required.

RECENT ANALYSES OF CANADIAN MINERALS AND RIVER WATERS.

From a recent Report by Mr. CHISTIAN HOFFMANN, F. Inst. Chem. to the Director of the Geological Survey.

CYANITE.

From the North Thompson River, British Columbia—Collected by Alfred R. C. Selwyn, Esq.

The mineral was imbedded in a granular quartz which, in addition, contained a few scales of a silvery-white mica. It, for the most part, occurred in in the form of radiated columnar aggregates, the colour of which was in parts pure blue, passing into greenish-grey; occasionally, but rarely, almost colourless—the other portions were of a uniform light bluish-grey colour. Lustre vitreous. Subtransparent. Specific gravity, 3.6005.

The material selected for analysis was found, after drying at 100° C., to have the following composition:

Silica	36.288
Alumina	62.254
Ferric oxide	0.552
Lime	1.064
Magnesia	0.355
	100.513

Previous to the finding of this specimen, cyanite was not known to occur in Canada.

LAZULITE.

Found three-quarters of a mile east of the mouth of the Churchill River,—District of Keewatin. Collected by Dr. R. Bell.

Occurs massive in veins, having a maximum width of seven millimetres, traversing a greyish-white, in parts milk-white, subtranslucent quartz. Colour fine deep azure-blue. Lustre vitreous. Fracture uneven. Brittle. Streak white. Subtranslucent. Hardness very nearly but not quite 5.5. Specific gravity—3.0445. Before the blow-pipe colours the flame pale bluish-green; swells up, whitens and falls to pieces, but does not fuse.

The material upon which the analysis was conducted, although selected with great care, and apparently pure, was nevertheless

found to contain 3.808 per cent. silica; in calculating the results this has been excluded; the composition of the mineral dried at 100° C., then being as follows:

Phosphoric acid	46.388
Alumina	29.140
Ferrous oxide	2.091
Magnesia	13.838
Lime	2.829
Water	6.468
	100.754

This is the first time that this interesting mineral has been met with in Canada.

WATERS OF THE ASSINIBOINE ANE RED RIVERS.

Geological character of the areas drained by these rivers.—The following information in connection with the subject has, at my request, been kindly furnished me by Dr. G. M. Dawson.

"The Red River, flowing from south to north, runs probably for its whole length over deposits of late date. These are, either the fine silty materials laid down in the bed of the southward extension of Lake Winnipeg, which previously occupied the valley; or clays and sandy clays due to the glacial period. Long and important streams, however, join the Red River, both from the east and west, and the character of the river water is doubtless due to the nature of the country occupied by the springs and sources of these, rather than to the composition of the bed of the main stream, with which the waters, passing rapidly and in large volume, cannot come very often or intimately in contact. Probably more than half of the water of this river is derived from the Rat, Roseau and Red Lake Rivers and other streams flowing from the wooded and marshy country in the east, and this it may be supposed does not differ much from that found in the rivers flowing from the woodland country in eastern Canada. This country is also covered with drift deposits of glacial and post-glacial age, and the streams seldom or never flow over solid rock. The tributaries from the west including the Shayenne, the Pembina and numerous smaller rivers, are from a region which may be regarded as almost altogether open prairie, and is subject to a rainfall considerably less in amount than that in the east. These streams flow in part over glacial and post-glacial deposits, but in part also over the underlying Cretaceous rocks, of which the shales and

clays of the Fort Pierre group cover the most extensive area. Springs, the water of which come in contact with the Cretaceous rocks also, doubtless feed the tributaries. The Cretaceous shales contain a considerable proportion of disseminated pyrites, which latter when exposed to atmospheric influences undergoes decomposition, ultimately giving rise, in the presence of the calcium carbonate contained in the rocks, to the formation of gypsum, with which mineral—generally in the crystalline form of selenite—many of the beds are in consequence charged. There are also on this side of the Red River, several springs impregnated with common salt; these resemble those of the Manitoba Lake district, and are probably like them derived from the underlying Devonian rocks. Springs of this character are known on the Salt River, south of the Pembina, and it was previously attempted to utilize these as a source of supply of salt. Similar springs are said also to occur on the Scratching River.

The country drained by the Assiniboine resembles in most points that described as giving rise to the other western tributaries of Red River. By some of the eastern branches of the upper part the Assiniboine, from Riding and Duck Mountains, a certain amount of woodland drainage is derived; but by far the greater part of its tributaries bring to it the drainage of prairie lands with a compartively small rainfall, and in which the saline matter, would therefore be supposed to exist in a more concentrated form. Though a compartively small portion of the total length of the streams can flow in actual contact with the underlying Cretaceous rocks, there is a reason to believe that in the praire region west of the valley of the Red River, a great part of the drainage of the country passes below the drift deposits along the surface of the underlying rocks, and this being brought very intimately in contact with these rocks would be likely to be influenced by their composition.

These samples of the waters were collected by Mr. A. S. Cochrane,—at the instance of Dr. R. Bell—on the 26th of October, 1876: that of the Assiniboine was taken from the centre of the river, about a quarter of a mile above its junction with the Red River; whilst the water of the latter was taken from the centre of the stream, about a quarter of a mile above where the former flows into it.

The water of the Assiniboine, after filtration, had a faint yellowish tinge. The suspended matter, which had a brownish-

grey colour, left on ignition a light reddish-brown coloured residue, this on examination was found to consist of argillaceous matter.

The water of the Red River, after filtration, had a pale yellowish tinge. The suspended matter was of a light brownish-yellow colour, on ignition it left a residue, which, as in the previous case, consisted of argillaceous matter.

The nature and amount of the organic matter contained in these waters was not ascertained,—the quantity of the water at disposal being altogether inadequate for the purpose,—apart from which, it is highly probable, that, during the interval of collection and analysis, the organic matter had, to some extent at least, undergone decomposition, the amount of carbonic acid therefore, although estimated, has not been given.

The analyses of these waters were conducted by Mr. Frank D. Adams, and the following are the results obtained by him, expressed in grains per imperial gallon :

	ASSINIBOINE.	RED RIVER.
Potassa	0.499	0.549
Soda	5.324	5.028
Lime	6.783	6.912
Magnesia	4.588	5.142
Alumina and ferric oxide (1)	0.084	0.092
Silica	1.571	2.208
Sulphuric acid	4.906	7.093
Carbonic acid	?	?
Chlorine	1.988	3.390
Organic matter	?	?
Oxygen equivalent to the chlorine	0.448	0.765
Total dissolved solid matter, dried at 100° C.	41.09	44.63

Suspended matter—	ASSINIBOINE.	RED RIVER.
Organic	0.692	0.342
Mineral	4.508	3.509
Total	5.200	3.851
Hardness (2)—		
Temporary	13.90	16.03
Permanent	6.70	7.87
Total	20.60	23.90
Specific gravity	1000.64	1000.52

The foregoing acids and bases are most probably combined in the water as follows:

(Carbonates calculated as mono-carbonates and all the salts estimated as anhydrous.)

Chloride of sodium	3.277	5.589
Sulphate of potassa	0.923	1.015
" of soda	8.216	4.727
" of lime	—	6.739
Carbonate of lime	12.112	7.388
" magnesia	9.635	10.798

1.—Although here given as ferric oxide, the iron was doubtless present in the water as a ferrous salt.—2. Direct method, Wanklyn and Chapman.

In the case of the Assiniboine water there was an excess of soda, above that required for the sulphuric acid, amounting to 0.114 grain (equals 0.084 sodium)—this might be present as carbonate: it would require 0.129 chlorine or 0.147 sulphuric acid in excess of the amounts found of these respective constituents. It has been calculated as, and added to the, sulphate of soda.

PROCEEDINGS OF THE NATURAL HISTORY SOCIETY.

The fifth regular meeting of the session 1880–1881, was held on the evening of Monday, March 28th. Principal Dawson occupied the chair.

The Sommerville Lecture Committee presented their report, which stated that the lectures had been a great success and more largely attended than in the past years.

The Chairman read the following interim report of the committee of council on the proposed meeting of the American Association for the Advancement of Science in Montreal in 1882:—

The Committee having met on Monday, March the 14th, requested Dr. T. Sterry Hunt to prepare a circular to be printed and sent to scientific men abroad, inviting them to attend the meeting: copies of this circular to be furnished to members of the Society and others willing to send them to their scientific friends.

It was further agreed to recommend that the President of the Society, Dr. Hunt, Mr. Selwyn and Dr. Osler, with any other

members of the Society who may attend the Cincinnati meeting of the Association, be requested to act as a delegation to promote the acceptance of the invitation tendered last August to the Association to meet in this city, and that the delegates be instructed to request that the meeting be held in the last week of August, 1882.

It was also agreed that so soon as the acceptance of an invitation is secured, lists shall be prepared of names of gentlemen to be invited, and that in the meantime the committee would make suggestions of names, and also of those who should be solicited to subscribe to a guarantee fund towards the expenses of the meeting, and to become members of the local committee.

It was understood that in the event of the acceptance of the invitation, the McGill University should be requested to allow the use of its hall and class rooms for the meetings and the lectures.

Dr. J. Baker Edwards read a paper entitled "Notes on dangerous Well-waters." Referring to the water supply of Lennoxville College, he said that a well being wholesome at one season was no reason for it always being so; it would make a material difference in the quality whether the well was two or eighteen feet deep; that the condition of a well which was regularly being filled by ample water rushes was totally different from that which would obtain during a winter frost. Therefore the sample of water he obtained from the well in August last might be totally different from that obtained from the same well by Prof. Croft of Toronto, in the depth of winter, and their difference was a difference of opinion only, not a difference of fact. His verdict was that the water was perfectly wholesome, that of Prof. Croft, that it was critical if not dangerous. Had the circumstances been the same it was possible no difference of opinion would have appeared. He than gave a detailed account of his analysis in August, 1880, and a description of the process employed, justifying his analysis of that date, and his opinion that the water was free from organic impurities, and especially sewage contamination. Speaking of disease arising from bad water, he said that the malaria affecting country districts seldom arose from the filtered water of wells, but rather from open meadows, marshes and inconstant streams. To a large extent the safety of a water supply depended on its recent filtration rather than on its source. He gave an account of the different kinds of well water and of the condition necessary to make the water wholesome.

MISCELLANEOUS.

Meteorological Results for the Year 1880.

McGill College Observatory, Montreal, Canada. C. H. McLeod, Superintendent. Height above sea level, 187 feet.

Month.	Thermometer.				* Barometer.				† Mean Pressure of Vapour.	‡ Mean relative humidity.
	Mean	Max.	Min.	Range.	Mean.	§ Max	§ Min.	Range.		
January	22.445	43.8	- 9.5	53.3	30.11781	30.864	29.487	1.377	.1048	77.6
February	19.888	51.2	-17.5	68.7	30.00822	30.540	29.340	1.200	.0974	73.0
March	22.086	49.6	-11.2	60.8	30.05803	30.695	29.228	1.467	.0896	69.3
April	39.599	63.4	10.2	53.2	29.87688	30.298	29.285	1.013	.1720	69.0
May	58.603	85.2	22.9	62.3	29.94195	30.360	29.537	0.823	.3349	63.8
June.	66.508	86.1	48.8	37.3	29.92147	30.235	29.487	0.748	.4363	67.1
July	69.282	86.2	52.7	33.5	29.88246	30.086	29.482	0.604	.4787	67.4
August	66.949	86.2	44.8	41.4	29.98902	30.369	29.556	0.813	.4459	68.2
September	60.312	85.0	40.3	44.7	29.95100	30.265	29.561	0.704	.4017	74.6
October	45.745	77.1	24.3	52.8	30.03562	30.400	29.374	1.026	.2490	78.0
November	29.099	59.0	2.2	56.8	30.15725	30.664	29.353	1.311	.1442	79.5
December	15.700	40.6	- 8.6	49.2	29.98282	30.579	29.488	1.091	.0809	82.3
Means for 1880	43.018	67.78	16.62	51.17	29.99354	.....	.....	1.015	.2529	72.[illegible]
Means for 6 years ending with '80.	42.471	.....	.....	....	29.96253	......	.....	....	.2562	74.80

Month.	Wind.		Sky clouded per cent.	Rain and snow melted.
	Mean direction.	Mean velocity in miles ℔ hour		
January	S.	13.61	63.6	3.03
February	S. W.	15.00	61.5	3.74
March	N.	11.70	48.0	2.55
April	W. S. W.	14.78	65.2	4.03
May	W. S. W.	12.45	60.8	2.97
June	S. W. by W.	8.73	54.6	3.27
July	S. W. by W.	8.69	53.5	5.35
August	W. S. W.	9.11	47.0	1.44
September	W. S. W.	9.65	67.8	2.83
October	S. W. by W.	11.00	66.5	4.75
November	S. W.	12.05	68.0	4.82
December	W. S. W.	11.26	75.2	2.11
Means for 1880	S. W. by W.	11.502	60.31	3.407
Means for 6 years, ending with 1880	W. by S.	11.077	62.02	3.301

* Barometer reduced to 32° Fah. and to sea level.
† In inches of mercury.
‡ Relative saturation 100.
The monthly means are derived from observations taken every fourth hour, beginning with 3.13 a.m.

The greatest heat was 86.2, on July 10th and August 24th. Greatest cold was 17.5 below zero on February 2nd. Extreme range of temperature for the year 103°.7. Greatest range of

thermometer in one day was 46.6 degrees the 30th January. The warmest day was the 4th of September, the mean temperature being 76.85. The coldest day was the 2nd of February, the mean temperature being 4.85 below zero. Highest barometer reading was 30.864 on January 29th. Lowest barometer reading was 29.228 on March 5th, giving a range for the year of 1.636 inches. The lowest relative humidity was 26, on March 26th. Greatest mileage of wind recorded in one hour was 47 on January 10th, when the greatest velociety was at the rate of 68 miles per hour.

NOTES:—Wheel traffic commenced on the 1st of April and closed on the 18th of November.

The heaviest rainfalls were on June 11th, 20th and on July 20th. The rainfall on July 20th measured 3.45 inches, which is the greatest amount recorded here for one day during the past six years. Of this rainfall 0.47 inches fell in 7 minutes and 1.58 inches in 46 minutes.

The first appreciable snow for autumn fell on the 26th October.

The earthquake noticed at Quebec on the 4th April was not felt here.

The ice in the river moved April 5th.

First arrival in port was on the 21st of April. The first arrival in the St. Lawrence from sea was on April 30th.

RAIN AND SNOW FALL DURING 1880.

MONTH.	Inches of rain.	No. of days on which rain fell.	Inches of snow.	No. of days on which snow fell.	Inches of rain and snow melted.	No. of days on which rain *and* snow fell.	No. of days on which rain *or* snow fell.
January	1.27	12	16 3	11	3.03	2	21
February	1.14	6	26.0	16	3.74	2	20
March	0.04	2	25 1	16	2.55	0	18
April	3 17	18	8 6	10	4 03	5	23
May	2.97	19	0.0	0	2.97	0	19
June	3.27	16	0.0	0	3.27	0	16
July	5.35	17	0.0	0	5.35	0	17
August	1.44	13	0.0	0	1.44	0	13
September	2.83	17	0.0	0	2.83	0	17
October	4.44	17	3.1	5	4.75	3	19
November	3.63	8	12.7	15	4.82	3	20
December	0.29	2	17.6	18	2.11	1	19
Totals	29.84	147	109.4	91	40.89	16	222
Means for six years ending with 1880	27.75	137.5	118.2	85.2	39.61	16.3	206.3

THE COLOR OF FLOWERS—At a recent meeting of the Vaudois Society of Natural Sciences, Professor Schnetzler read an interesting paper on the color of flowers. It has been generally supposed that the various colors observed in plants were due to so many different matters, each color being a different chemical combination without relation to the others. Now Professor Schnetzler shows by experiments that when the coloring matter of a flower has been isolated, by means of spirits of wine, one may, by adding an acid or alkaline substance, obtain all the colors which plants present. Flowers of peony, give, when placed in alcohol, a red-violet liquid. If some salt of sorrel be added, the liquid becomes pure red; while soda changes it, according to the quantity, into violet, blue, or green. In this latter case the green liquid appears red by transmitted light, just as does chlorophyll (the green coloring matter of of leaves). The sepals of peony, which are green with red border, become wholly red when put in salt of sorrel. These changes of color, which can be had at will, may quite well be produeed in the plant by the same causes, for in all plants there are always acid or alkaline substances. Further, it is certain that the transformation from green into red, observed in the leaves of many plants in autumn, is due to the action of tannin, which they contain, with chlorophyll. Thus without wishing to affiirm it absolutely, Professor Schnetzler supposes *à priori* that there is in plants only one coloring matter —chlorophyll—which being modified by certain agents, furnishes all the tints which flowers and leaves present.

NIAGARA FALLS DRY FOR A DAY.—The Lord Bishop of Niagara recently lectured in Hamilton, Ont. on "Upper Canada as it was fifty years ago, and Ontario as it now is," and in the course of his remarks said: "The falls of Niagara were dry for a whole day. That day was the 31st of March 1848. I did not witness it myself; bnt I was told of it the next day by my late brother-in-law Thomas C. Street, Esq. Mr. Street's theory was this: That the winds had been blowing down Lake Erie, which is only about 30 feet deep, and rushing a great deal of water from it over the Falls, and suddenly changed and blew this little water (comparatively speaking) up to the western portion of the lake and that at this juncture the ice on Lake Erie, which had been broken up by the high winds, got jammed in the river bet-

ween Buffalo and the Canada side, and formed a dam which kept back the waters of Lake Erie a whole day." One of the local papers noticing his lordship's lecture spoke of the statement concerning the Falls as "rather fishy." The lecturer then sent to the sceptical editor declarations from several gentleman all corroborating his statement.

The Hon. L. F. Allen of Buffalo declared: "I well recollect it, although I have no precise date as to the month or year in which it occurred. It was so remarkable as to be noticed in Buffalo newspapers. Nor do I recollect whether the subsidence of the river waters was caused by a dam of ice at the outlet of Lake Erie or by a strong east wind, which sometimes, by blowing the water up the lake, makes very low water in the river for many hours.

Two other witnesses made the following statutory declarations; (the laws of Ontario forbid taking oath in such cases).

County of Welland, to wit: I, Henry Bond, of the Village of Chippewa, in the County of Welland, blacksmith, do solemnly declare that I well remember the occurrence of there having been a day during which so little water was running in the Niagara River that but a small stream was flowing over the Falls of Niagara during that day. It happened on or about the 31st day of March, A. D. 1848.

HENRY BOND.

Declared before me, at Chippewa, in the County of Welland, this 17th day of May, A.D. 1880.

J. F. MACKLAN, Notary Public.

County of Welland, to wit: I, James Francis Macklan, of the Village of Chippewa, in the County of Welland, Province of Ontario, notary public and Justice of the Peace, do solemly declare that about the 31st day of March, A. D. 1848, the waters of the Niagara River were so low that comparatively little was flowing over the Falls for a whole day. "The phenomenon of the Falls of Niagara running dry," as was the term used in speaking of the occurrence, caused great excitement in the neighbourhood at the time.

J. F. MACKLAN,

Notary Public and Justice Peace for County of Welland.

CHIPPEWA, May 17, 1880.

Published 30th April, 1881.

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

DISCOVERY OF THE PREGLACIAL OUTLET OF THE BASIN OF LAKE ERIE INTO THAT OF LAKE ONTARIO; WITH NOTES ON THE ORIGIN OF OUR LOWER GREAT LAKES.

The above is the title of a lengthy paper by Prof. J. W. Spencer, of King's College, Windsor, N. S., read before the American Philosophical Society in March last.

We present our readers with the more important parts of the paper concerning the Preglacial Outlet of Lake Erie and a summary of the whole.

Basin of Lake Ontario. As is well known, Lake Ontario consists of a broad, shallow (considering its size) basin, excavated on the southern margin out of the Medina shales, and having its southern shores from one to several miles from the foot of the Niagara escarpment. The Medina shales form the western margin (where not covered with drift) to a point near Oakville. From this town to a point some distance eastward of Toronto, the hard rocks are made up of the different beds of Hudson River Epoch; while the soft Utica shales occupy the middle portion, and the Trenton limestones the portion of the Province towards the eastern end of the lake.

The country at the western end of the lake consists of slopes gently rising to the foot of the Niagara escarpment. Sometimes this elevation is by terraces, and again by gentle inclines, as between the foot of the encarpment at Limehouse (on the G. T. Railway) and the lake, where the difference of altitude above the water is more than 700 feet, without any very conspicuous features.

Basin of Lake Erie. The exceedingly shallow basin of Lake Erie has its bottom as near a level plane as any terrestrial tract could be. Its mean depth, or even maxima and minima depths from its western end for more than 150 miles, scarcely varies from 12 or 13 fathoms for the greater portion of its width. The eastern 20 miles has also a bed no deeper than the western portion. Between these two portions of the lake, the hydrography shows an area with twice this depth (the deepest sounding being 35 fathoms). This deepest portion skirts Long Point (the extremity, a modern peninsula of lacustrine origin), and has a somewhat transverse course. An area of less than 40 miles long has a depth of more than 20 fathoms. The deeper channel seems to turn around Long Point, and take a course towards Haldimand county, in our Canadian Province, somewhere west of Maitland. The outlet of the lake, in the direction of the Niagara river, has a rocky bottom (Corniferous limestone).

The study of this lake at first appears less practicable than that of Ontario, but, when its former outlet and its tributary rivers are described, the writer trusts that he will have made some observations, that may help to clear the darkness that hangs about the history of our interesting lake region, before the advent of the Ice Age.

The Dundas Valley and adjacent Cañons. We may consider that the Dundas valley begins at the "bluff" east of the Hamilton reservoir, and extends westward, including the location of the city of Hamilton and the Burlington Bay, at least its western portion. With this definition, the width at the Burlington heights (an old lake terrace 108 feet above present level of the water) would be less than five miles. At a mile and half westward of the heights, the valley suddenly becomes narrowed (equally on both sides of its axis of direction, by the Niagara escarpment making two equal concave bends, on each side of the valley, whence the straight upper portion extends, the whole resembling the outline of a thistle and its stem), from which place it extends six miles westward to Copetown, on the northern side; and three and a half to Ancaster, on its southern side. The breadth between the limestone walls of this valley varies somewhat from two to two and a half miles. The summit angles of the limestone walls on both sides are decidedly sharp.

Dundas town is situated in this valley, its centre having a height about 70 feet above Lake Ontario, but its sides rise in

terraces or abrupt hills; and on ascending the valley, we find that between the escarpments are great ranges of parallel hills separated by deep gorges or glens, excavated in the drift by modern streams. This rugged character continues until the summit of the Post Pliocene ridges have a height equal to that of the escarpment. As the gorges ascend towards the westward they become smaller, until at some distance south-west of Copetown and Ancaster, the divide of the present system of drainage is reached. Some of these streams have cut through the drift, so that they have only an altitude above the lake (which is seven miles distant) of 240 feet, while the tops of the ridges immediately in the neighborhood are not much less than 400 feet high though they themselves have been removed to a depth of about another hundred feet, for the drift has filled the upper portion of the valley to the height of 500 feet above Lake Ontario. Even to the very sources of the streams, the country resembles the rivers of our great North Western Territories (or those of the Western States), cutting their way through a deep drift at high altitudes, which is not underlaid by harder rocks, showing deep valleys rapidly increasing in size and depth, as they are cleaning out the soft material, and hurrying down to lower levels—a strong contrast to the features in most other portions of our Province.

On the south side of the Dundas valley, a few unimportant streams, mostly dry in summer, have worn back the limestone escarpment, over which they flow, to distances varying from a few yards to a few hundred, making glens at whose head in spring-time some picturesque cascades can be seen. At Mount Albion, six miles east of Hamilton, there are two of these larger gorges, whose waters, after passing over picturesque falls, 70 feet high, and through glens several hundred yards in length, empty into the triangular valley noticed before. On the north side of the Dundas valley, besides small gorges with their streams comparable to those on the south side, there are several of much larger dimensions; for example, that at Waterdown, six miles north of Hamilton. Still larger is Glen Spencer which has a *cañon* half a mile long, 300 feet deep, and between 200 and 300 yards wide at its mouth. At the head of this is Spencer Falls, 135 feet high, and joining it laterally there is another *cañon*, with a considerable stream flowing from Webster's Falls, which however, is of less height than the other. The waters feeding these

streams come from northward of the escarpment, and belong to a system of drainage different from those streams which flow down through the drift of the Dundas valley and are of much greater length. At the foot of Spencer Falls, the waters strike the upper portion of the Clinton shaly beds. The Falls now are two feet deeper than twenty years ago. Yet the stream is small, and makes a pond below in the soft shales. But this difference in height does not represent the rate of wearing or recession of the precipice. That the stream is much smaller than formerly is plainly to be seen, for at present it has cut a narrow channel, from ten to fifteen yards in width, above the falls, and from four to six feet deep on one side of the more ancient valley, which is about 50 yards wide and 30 feet deep, excavated in the Niagara dolomites.

The surfaces of the escarpment in both sides of Glens Spencer and Webster present a peculiar aspect. That on the north-eastern side has a maximum height of 520 feet above the lake. On the same side, a section made longitudinally shows several broad shallow glens nearly a hundred feet deep crossing it and entering Glen Spencer. The surface of the rocks is glaciated, but not parallel with the direction of the channels. On the south-western side of the same *cañon*, we find that a portion of the thin beds of Upper Niagara limestone have been removed. This absence is not general, for it soon regains its average height of about 500 feet.

The Grand River Valley. The Grand River of Ontario rises in the County of Grey, not more than twenty-five miles from Georgian Bay. Thence it flows southward, and at Elora the river assumes a conspicuous feature. Here it cuts through the Guelph dolomites to a depth of about 80 feet and forms a *cañon* about 100 feet in width with vertical walls. At this place it is joined by a rivulet from the west, which has formed a tributary *cañon* similar to that of the Grand River itself.

The country in this region is so flat that it appears as a level plane. Farther southward the river winds over a broader bed, and at Galt the present river valley occupies a portion of a broad depression in a country indicating a former and much more extensive valley. In fact the old river valley existed in Preglacial times, for the present stream has re-excavated only a part of its old bed at Galt, leaving on the flanks of one of its banks (both of which are composed of Guelph dolomites), a deposit of Post

Tertiary drift, in the form of a bed of large rounded boulders mostly of Laurentian gneisses. The country for four miles south of Galt is of similar character, forming a broad valley, in which the present river flows. At this distance from Galt the river takes a turn to the south-westward; but at the same place, the old valley appears to pass in a nearly direct line with the course of the present bed (before the modern turn is made to the westward). As this portion of the valley now entered, has not to any extent been cleaned out by modern streams, it forms a broad shallow depression in the country extending for a few miles in width. Yet it is often occupied with hills composed of stratified coarse gravel belonging to that belt, which extends from Owen Sound to the County of Brant, and called by the Canadian Geological Survey "Artemesia Gravel."

It is through a portion of this valley that the Fairchild's Creek flows. Many streams derive their supplies of water from the Beverly swamps, which also feed the Lindsay Creek, that empties over Webster Falls and flows down Glen Spencer through the Dundas valley to Lake Ontario.

The G. W. Railway, at four miles south of Galt, enters this valley and continues in it or its branches as far as Harrisburg, though the deeper depression is near St. George (a short distance west of Harrisburg). After leaving what I consider its more ancient bed, south of Galt (unless the country between the present bed and Fairchild's Creek was an island), the Grand River flows southward to Paris and Brantford, having a deep, broad valley. At the latter place the valley may fairly be placed at a few miles in width, while further to the eastward the river winds in an old course which had formerly a width of four miles. In the region of Brantford the valley is bounded by a somewhat elevated plateau. At Paris, Neith's Creek enters the Grand River from the west, and has a valley almost comparable in size with that of the latter at this town. At Paris, the Grand River cuts through the plaster-bearing Onondaga formation. Similar rocks appear at various places along the river, at places where the river has cleaned out a portion of one side of its ancient valley.

At the Great Western Railway crossing, east of Paris, the bed of the river has an altitude of 495 feet above Lake Ontario, while at Brantford it is 410 feet (this elevation may not be perfectly accurate) above the same datum. From Brantford the river winds through a broad valley, with a general easterly direction,

to Seneca, where the immediate bed is about quarter of a mile wide, flowing at the southern side of a valley, more than two miles wide, and 75 feet below its boundaries, which are 440 feet above Lake Ontario. At Seneca the bed of the present river-course is 365 feet above Lake Ontario or only 37 feet above Lake Erie. (The H. & N. W. Railway levels give Lake Erie as 328 feet above Lake Ontario, whilst the Report of the Chief Engineer of the Welland Canal states that the difference of level is 326¾ feet. As these two levels agree so nearly, and as the other figures refer to the railway levels, I have followed them here.) Eastward from Seneca the river continues to have its broad valley as far as Cayuga. To near this town the waters of the Welland canal feeder reach, at a height of about 9 (?) feet above Lake Erie.

From Seneca to Cayuga the direction of the valley is nearly south, but at the latter place it abruptly turns nearly to the eastward, and in a short distance it passes to a flatter country and flows over Corniferous limestone. After a sluggish flow, it enters Lake Erie, (passing through a marshy country) at Port Maitland more than fifteen miles in a direct line from Cayuga. It must be remembered that, from Seneca to Cayuga, the valley is broad and conspicuous. At only a short distance south of the river, at Seneca, the summit of the country is occupied by a gravel ridge.

Returning to the valley of Fairchild's Creek, we find the stream principally flowing in the former bed of the Grand River, abandoned a few miles below Galt since the Ice Age. This creek crosses the Great Western Railway at a level of fifteen feet below the crossing of the Grand River, at a few miles to the westward. Again, the Fairchild's Creek crosses the Brantford and Harrisburg railway at an altitude of 407 feet above Lake Ontario, or a little below that of the Grand River at Brantford, although it empties into it a few miles east of the city just named.

Fairchild's Creek is now of moderate size meandering through the drift for a width of two miles. This drift is in part stratified clay. The Grand River from Brantford eastward, is generally excavated from the drift deposits, although occasionally one side of the valley shows rocks of Onondaga formation, exposed by the removal of the drift in modern times. It is also desirable to call attention to the fact that in the region of Brantford, much of the Onondaga Formation is shaly and forms the surface country-rock, covering a broad belt, whilst from Seneca eastward

the surface of the country is more generally covered with Corniferous limestone.

Country between the Grand River and Dundas Valleys. The watershed between these two present drainage systems is at only a short distance southwest of Copetown, and the distance in a direction from the Fairchild's to the Dundas side of this divide is less than seven miles, with an average altitude of less than 480 feet (the same as that of the Fairchild's Creek, as it crosses the Great Western Railway). The highest point that I have levelled is 492 feet above Lake Ontario. On receding westward from the divide, the country gradually descends to the Fairchild's Creek, which as it crosses the Brantford and Harrisburg Railway is 407 above the Lake. It is considerably lower where it enters the Grand River. The region between the divide and the Grand River is traversed from north-west to south-east by a considerable number of streams, all with relatively large valleys, cut in the drift, since the present system of drainage was inaugurated in Post Glacial times.

The country from Jerseyville (about 465 feet above lake) slopes gradually to the Grand River, from six to eight miles distant to the southward.

On examination, it may be seen that the country is too high to permit the Fairchild's Creek or Grand River, as they are at present situated, to flow over the height of land into the upper portion of the Dundas valley. As referred to before, the Niagara limestone forming the summit of the escarpment at Ancaster and eastward has a height of about 500 feet. These beds dip at only about 25 feet in a mile (to about 20 degrees west of south) and are not generally covered by a great thickness of drift, but in many places are exposed on or near the surface. Westward of Ancaster these limestones are nowhere to be found, but the country is covered only with drift. At a short distance west of this village, we find streams flowing north-easterly and easterly with very deep valleys in the drift, indicating the absence of the floor of limestone to a depth of over 250 feet below the surface of the escarpment. But on going westward we find that the streams have not cut to an equal depth, but are still running deeply through drift. Eventually we reach the divide, after which we find that other systems of streams also cut deeply in the drift running in a south-easterly direction to join the Grand River; but the Niagara limestone is absent from a considerable extent of country.

On the northern side of the Dundas valley the escarpment after reaching Copetown is buried by the drift. Although the line of buried cliffs recedes somewhat to the northward of the Great Western Railway, yet there are occasional exposures, as at Troy and other places in Beverly and Flamboro, where the underlying limestones come to the surface. At Harrisburg the limestones are known to be absent for a depth of more than 72 feet, as shown in a deep well in the drift.

In the town of Paris one well came upon hard rock at 10 feet below the surface, whilst another at 100 feet in depth reached no further than boulder clay. This last well must have been in a buried channel of Neith's Creek, as outcrops of gypsum-bearing beds of the Onondaga formation frequently occur near the summit of the hills. From what has just been written, it is easily seen that the Niagara limestones are absent from a more or less horizontal floor (which is over 500 feet above the lake, on both the northern and southern sides of the Dundas valley) which continues from Dundas westward to near Harrisburg, where it meets a portion of the Grand River valley. But almost immediately west of Ancaster we find streams running northward at right angles to the escarpment, and cutting through drift to the depth of almost hundreds of feet. In fact, if we draw a line from Dundas to northward of Harrisburg (a mile or two), and another from Ancaster southward to the Grand River, we have two limits of a region where the limestone floor has been cut away from an otherwise generally level region. The southern side of the area is the southern margin of the Grand River valley, between Seneca and Brantford; and the western boundary is composed of Onondaga rocks east of Paris (which perhaps forms an island of rocks buried more or less in drift).

The Buried River Channel in the Dundas Valley and its Extensions. That the Dundas valley is that of an ancient river valley now buried to a great depth with the *débris* produced in the Ice Age, becomes apparent on a careful study of the region. However, until a key was discovered the mystery of its origin was found to be very obscure. My own labors at studying this region may fairly be stated as the first systematic attempts at the solution of the present configuration of the western end of Lake Ontario and the adjacent valley. Assertions have been made that it was scooped out by a glacier, but this wild hypothesis was only a statement made without any regard to facts.

From the topography, it is be seen that the apparent length of the rock-bound valley is six miles, with a width of over two miles; then it widens suddenly to four miles (with concave curves on both sides), after which it gradually increases in width as it opens into Lake Ontario. The direction of the axis of the valley is about N. 70° E. The summit edges of the rock walls are sharply angular and not rounded or truncated. This angularity is not due to frost action since the Ice Age, to any extent, as is shown by the character of the talus. The rocks of the summit are frequently covered with ice markings, but I am not aware of any locality where they have been observed as being parallel with the true direction of the valley, but on all sides one can observe them (sometimes at only small angles of less than 30 degrees) making conspicuous angles with its axis. One exception may be made to this statement. On a projecting ledge of Clinton limestone, at Russel's quarry, near Hamilton, at a height of 254 feet above the lake, and 134 feet below the summit of the "mountain," after the removal of some talus, I observed that the surface was polished but with scratches so faint that they could scarcely be compared with those of fine sand-paper on wood; and the direction if determinable, was parallel with the overhanging escarpment. There are many tributary *cañons*, which are evidently of greater antiquity than the Ice Age, which could not have been excavated by the present streams, and are at all sorts of direction compared with the striated surface of the country.

The topography of the lower lake regions precludes the idea of a glacier flowing down the valley to the north-eastward. Again, as the direction of the ice was towards the south-west, the waters from the melting glaciers could scarcely flow up an escarpment many hundreds of feet in height. Even if the Niagara escarpment did not exist elsewhere, the non-parallelism of the striæ, and edges of the escarpment with their angular summits, is sufficient to prove the non-glacial origin of the valley in the hard limestone rocks. Moreover, at the eastern end of the narrower portion of the valley, there are two concave curves facing the lake, which of necessity would have been removed if such a gigantic grinding agent had been moving up the valley.

The glacier-origin of the valley being an absolutely untenable hypothesis, I sought for some fluviatile agent capable of effecting the present configuration of the region. At the time, no idea occurred that even the great valley of the present is only a miser-

able remnant of one of gigantic proportions obscured by hundreds of feet of drift. The question arose, could Lake Erie have ever emptied by this valley? This suggestion did not hold its ground for any length of time, because the present levels are all too high. Near Galt, the traces of the true origin first presented themselves. A branch of the Great Western Railway extends from Galt southward for about four miles in the valley of the Grand River, after which, without making any important ascent, it passes into the broad older valley, described above as that in which Fairchild's Creek now flows. After a careful examination of the region and of the railway levels, I came to the conclusion that it was an old buried valley. It then became apparent that if the Grand River had occupied the site of the Fairchild's Creek, that the latter probably flowed down the Dundas valley, and that the Grand River, being one of the largest of the rivers of Ontario, might have been a sufficient cause for the great excavation at the western end of Lake Ontario. Having procured all the levels that bore on the subject which were available, it became necessary to connect several places myself by instrumental measurements, which work was accomplished last July, with the aid of Prof. Wilkins. As the whole floor of Niagara limestones is absent, as has previously been shown, the proof that the ancient Grand River flowed down the Dundas valley was completed, and of this discovery there was published a local notice last August. Significant and interesting as this fact was, relative to the change of systems in our Canadian drainage, a still more important issue was involved. When taking the levels between the Dundas valley (modern) and the Grand River, it was found that the whole calcareous floor was removed from a basin several miles in width, and that all the wells were sunk to a considerable depth in the drift before water could be obtained. On glancing at the map it will be seen that the Grand River from Brantford to Seneca meanders through a broad course, which in its ancient basin is several miles in width, but that from Seneca the valley is narrower, and the course of the stream more direct, as far as Cayuga. At Seneca the valley is two miles wide and seventy-five feet deep. Also the bed of the Grand River at Seneca is in drift which is only 37 feet above the lake into which it now empties. This broad valley continues to Cayuga within a few miles of the lake, whence its former probable course was by nearly direct line to Lake Erie, now filled with drift, near the present bend in the river towards the eastward. At Cayuga

the rock beneath the drift-bed of the river is below the lake level, on the margin of the ancient valley.

Having observed the connection between the Dundas valley, Grand River and Lake Erie, it dawned on me that I had established the knowledge of a channel having a very important bearing on the surface geology of the lake region. It now became apparent that Lake Erie had flowed by the Grand River (reversed) to a point west or north-west of Seneca, and thence by the Dundas valley, into Lake Ontario; also that the upper waters of the Grand River, previously discovered as passing down the Dundas valley, were really tributary to the outlet of Lake Erie, and joined it somewhere south of Harrisburg; and that the basin between Brantford (and the Grand River of to-day) and the Great Western Railway, at Copetown, formed an expanded lakelet along the course of the ancient outlet of Lake Erie, scooped out of the softer rocks of the Onondaga Formation before noticed. As the waters excavated a bed in a deeper channel, of course this lakelet would become an expanded and depressed valley, such as we often see amongst the hills of drift, at a short distance westward of Dundas. Possibly the Grand River divided and flowed around an island, the western side of which is occupied now by the town of Paris. At any rate, Neith's Creek, at that town formed a large tributary to the river then flowing down to Lake Ontario.

Along the course from Cayuga to Lake Ontario all obstacles to the outlet of Lake Erie appear to be removed. But along the present course of the Grand River, eastward of Cayuga, the waters flow over Corniferous limestone. But this difficulty is removed on observing that the river, filled with drift, approaches Lake Erie to within a direct distance of about six miles, but at this place it leaves its southward course and also its conspicuous valley and flows eastward, in the same manner as the Niagara River, above the Whirlpool, left its old choked-up outlet by the valley of St. David, and cleaned out a new channel for itself through several miles, in hard rock, from Queenstown southward.

We have seen that the Grand River bed is near the eastern margin of its ancient valley at Cayuga. From northward of this town at about half a mile to the westward of the river, a deep depression in the drift indicates the deeper portion of the ancient river as it left the modern channel direct for the Lake Erie basin. Also along this route the hard rock is known to be absent to a depth below the surface of Lake Erie.

In Ohio, the Geological Survey considers that Maumee River emptied into the Wabash. If the waters of Lake Erie ever passed by this route into the Mississippi river when they were at no higher level than at present, then there must be a channel buried to a depth reaching at least 170 feet above the lake, as that is the elevation of the divide between the upper waters of these two rivers.

The outlet of Lake Erie, indicated in this paper, is known at many places along its route to have no rock-bed for a distance below the surface of the higher lake, and to a probable depth sufficiently great to empty Lake Huron.

Again Mr. Carll has shown that the Alleghany drainage passed near Dunkirk into the Erie basin at a place just opposite to its outlet, as indicated by the present writer.

Much of the Dundas valley is underlaid by stratified Erie clay, which is known to extend to a depth of 60 feet below the surface of Lake Ontario, according to Dr. Robert Bell. In the upper part of the valley, streams have exposed some deposits of unstratified clay filled with angular shingle, derived from the thin beds of limestone forming the upper portion of the Niagara Formation. In the eastern portion of the valley, the Erie clay is overlaid unconformably by brown Saugeen clay or loam (stratified). In the upper portions of the valley the hills are capped by brown clays or sands. But along some of the hillsides excavated so deeply in the drift, we find old beaches resting unconformably on boulder clay.

Near the centre of the city of Hamilton, in the wider portion of the Dundas valley, a well was sunk to the depth of over 1000 feet. This well revealed a most interesting fact. Though known to me several years ago, I did not apply it until recently to its true bearing, since discovering the origin of the Dundas valley. Mr. J. M. Williams sunk this well, at the Royal Hotel, in Hamilton. He told me several years ago that he had to sink through 290 feet of boulders, before coming to hard rock, thus causing the outlay of a large sum of money in excess of his calculations. Unfortunately, this well-record has been lost by fire. At that time, the fact was so fresh in his memory (improved by the extraordianary cost of the well) that his statement could be relied on, he being experienced in well-borings. The mouth of this well is 63 feet above Lake Ontario, and therefore the hard rocks are absent for a depth of 227 feet below the lake surface.

As the valley is five miles wide at this place, and as the well is only about one mile distant from its southern side, it becomes apparent that the valley in the centre must have been much deeper. Moreover if we produce the southern side of that portion of the valley, which is over two miles wide, we find that the well is less than a quarter of a mile away from it. Now if we connect the top of the Medina shales (240 feet above Lake Ontario) with the base of the drift in the well, and produce it to the centre of the valley, it would indicate a central depth of over 500 feet. At the base of the drift there are nearly fifty feet of Medina shales, below which are the Hudson River rocks (more or less calcareous and arenaceous. mixed with the shales). This harder formation along the bed of the river would be less extensively removed by aqueous action than the overlying Medina shales, especially as the pitch of the waters would be much lessened. This graphic method of calculation seems as perfectly admissible here as it does in determining other constants of nature. However, I have placed the estimated depth in the section at about 70 fathoms below the lake surface, which depth is perfectly compatible with the soundings of the lake at no very great distance to the eastward. Even this depth gives only very gentle slopes from the sides of the river valley. It should be remarked that Burlington Bay is excavated from stratified clays in places to a depth of 78 feet. But this water is silting up comparatively quickly.

Now we have seen that the deep excavation in the Dundas valley and westward is cut through more than 250 feet of Niagara and Clinton rocks, mostly of limestone, and to a depth in the Medina shales, so that the total known depth of the *cañon* is 743 feet, but with a calculated depth in the middle of the channel of about 1000 feet. This depth for a *cañon* is not extraordinary for Eastern America. In Tennessee there are river valleys excavated to a depth of 1600 feet, and in Pennsylvania Mr. Carll reports others to be equally deep.

Again, this Preglacial river explains the cause of the present topography of the western end of Lake Ontario. The drainage by this river swept past the foot of the submerged escarpment of Lake Ontario, until it passed the meridian of Oswego.

With such an outlet, and with the ancient Grand River valley buried to an equal depth, we have an easy solution to the problem of the drainage of Lake Erie.

The following is Dr. Spencer's summary of the whole paper:

1. The Niagara escarpment, after skirting the southern shores of Lake Ontario, bends at nearly right angles in the neighborhood of Hamilton, at the western end of the lake; thence the trend is northward to Lake Huron. At the extreme western end of the lake this escarpment (at a height of about 500 feet) encloses a valley gradually narrowing to four miles, at the meridian of the western part of the city of Hamilton, where it suddenly closes to a width of a little more than two miles, to form the eastern end of the Dundas valley (proper). This valley has its two sides nearly parallel, and is bounded by vertical escarpments, which are capped with a great thickness of Niagara limestone, but having the lower beds of the slopes composed of Medina shales. On its northern side the escarpment extends for six miles to Copetown; westward of this village it is covered with drift, but it is not absent. On its southern side the steep slopes extend for less than four miles to Ancaster, where they abruptly end in a great deposit of drift, which there fills the valley to near its summit, but which is partly re-excavated by the modern streams, forming gorges from two to three hundred feet deep. To the north-eastward of Ancaster these gorges are cut down through the drift to nearly the present lake level.

Westward of Ancaster, a basin occupying a hundred square miles, where the drift is found to a great depth, forms the western extension of the Dundas valley. With the north-western and western portions of this drift-filled area the upper portion of the Grand River and Neith's Creek were formerly connected. The Grand River, from Brantford to Seneca, runs near the southern boundary of this basin, then it enters its old valley, which extends from Seneca to Cayuga, with a breadth of two miles, and a depth, in modern times, of seventy-five feet, having its bed but a few feet above the surface of Lake Erie. Near Cayuga, the deepest portion of the river-bed is below the level of Lake Erie.

2. The Dundas valley and the country westward form a portion of a great *river valley*, filled with drift. Along and near its present southern margin this drift has been penetrated to 227 feet below the surface of Lake Ontario, thus producing a *cañon* with a lateral depth of 743 feet, but with a computed depth, in the middle of its course, of about 1000 feet.

3. The Grand River, at four miles south of Galt, has since the Ice Age, left its ancient bed, which formerly connected with that of the Dundas valley, as did also Neith's Creek, at Paris.

4. Lake Erie emptied by a buried channel a few miles westward of the present mouth of the Grand River, and flowed for half a dozen miles to near Cayuga, where it entered the present valley, and continued this channel (reversed) to a place at a short distance westward of Seneca, whence it turned into the basin referred to above, receiving the upper waters of the Grand River and Neith's Creek as tributaries, and then emptied into Lake Ontario, by the Dundas valley. This channel was also deep enough to drain Lake Huron.

5. Throughout nearly the whole length of Lake Ontario, and at no great distance from its southern shore, there is a submerged escarpment (of the Hudson River Formation) which, in magnitude, is comparable with the Niagara escarpment itself, now skirting the lake shore. It was along the foot of this escarpment that the river from the Dundas valley flowed (giving it the present form) to eastward of, or near to, Oswego, receiving many streams along its course.

5. The western portion of the Lake Erie basin, the southwestern counties of Ontario, and the southern portion of the basin of Lake Huron formed one Preglacial plane, which is now covered with drift or water (or with both) to a depth varying from fifty to one hundred feet, excepting in channels where the filling by drift is very great. A deep channel draining Lake Huron extended through this region, leaving the present lake near the Au Sable River, and entering the Erie basin between Port Stanley and Vienna, at a depth near its known margin of 200 feet, but at a probable depth in the centre sufficiently great to drain Lake Huron.

6. The Preglacial valleys (now buried) of Ohio and Pennsylvania—for example; the Cuyahoga, Mahoning (reversed), and Alleghany (deflected), formed tributaries to the great river flowing through the Erie basin and the Dundas valley.

7. The bays and inlets north of Lake Huron are true fiords in character, and are of aqueous origin.

8. The Great Lakes owe their existence to sub-aërial and fluviatile agencies, being old valleys of erosion of great age, but with their outlets closed by drift. Glaciers did not excavate the lakes and had no important action in bringing about the present topography of the basins.

9. The old outlet of the Niagara river, by the valley of St. David's, was probably an interglacial channel.

A BLASTOID FOUND IN THE DEVONIAN ROCKS OF ONTARIO.

By Henry Montgomery, M.A.,

Science Master in the Collegiate Institute, Toronto.

In the month of July 1879, while examining the Hamilton Group of the Devonian Series of rocks in the south-western part of the Province of Ontario, I had the good fortune to discover an apparently rare fossil Echinoderm imbedded therein. It was taken by me from a limestone quarry near Thedford or Widder village in the township of Bosanquet, county of Lambton. Soon afterwards I learnt that Dr. George Jennings Hinde had, a short time previously, obtained a specimen of the same species from the rocks of the same region, but it was not in so good a state of preservation as the one which I had found. It is regretted that, notwithstanding repeated and careful searches since that time, I have been unable to procure more than a single specimen of this form, which seems also to be exceedingly rare (if indeed it occurs) in the United States. Although it appears to be a variety of the Nucleocrinus lucina, a new species collected by Mr. C. A. White from the Hamilton shales, Livingstone Co., New York State, and described by Professor James Hall in 1862, yet it does not seem to have been described or even mentioned as occurring in Canadian rocks. Nor am I aware that any representative of the genus Nucleocrinus, and indeed it may be said, of the entire order Blastoidea (unless the Codaster or Codonaster Canadensis of Billings be referred to this order), has ever been described from the rocks of Canada. Therefore I have thought it advisable to publish figures and a description of the specimen alluded to, at the same time contrasting it with *Pentremites Godoni*, several excellent specimens of which, as well as of *P. pyriformis*, of the Sub-Carboniferous rocks of Illinois, are in my cabinet.

For assistance kindly extended to me in the study of this extinct form and its relations I am deeply indebted to my friend and instructor Dr. E. J. Chapman of University College, Toronto. Several very valuable hints were likewise furnished me by Dr. Hinde, F.G.S., New South Kensington Museum, London, England, and Mr. J. F. Whiteaves, F.G.S., Canadian Geological Survey.

Mr. Conrad named the genus Nucleocrinus (L. *nucleus* kernel of a nut, and Gr. *krinon* a lily) in 1842; Troost gave it the generic name Olivanites in 1849; and in 1852 Dr. Ferd. Rœmer called it Elæacrinus. In 1862 Dr. Hall gave the name *lucina* to a species gathered from the rocks of the State of New York. To this species, in the absence of specimens of lucina with which to compare it, I provisionally refer what may possibly be a *new* species of Nucleocrinus.

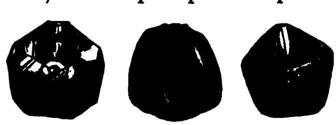
The echinoderm in question, found as already stated, in the Hamilton formation, Lambton Co., was associated with numerous corals, chiefly of the genera Cystiphyllum, Diphyphyllum, Eridophyllum, Heliophyllum, Stenopora, Favosites, Alveolites and Aulopora, with various Brachiopods (Spirifera, Spirigera, Strophomena, Strophodonta, Cyrtina, Chonetes, etc.), Gasteropods, and Bryozoa. It must be placed in that division of the Blastoidea possessed of a calcareous, jointed stem and a lateral interambulacral aperture. In general appearance it is somewhat barrel-shaped, being thicker a little above the middle than at either extremity, and considerably flattened at the summit and base. Its greatest length is about 4½ lines; and its greatest transverse diameter about 3¾ lines.

FIG. 1.

a. *b.* *c.*

FIG. 1. Nucleocrinus lucina (?). From the Hamilton shales, Ontario, Canada. *a.* View of base, twice the natural size, shewing point of attachment of stem, and the five radials bearing each a long, central elevation terminating in a concave projection over the end of the pseudambulacrum. *b.* Lateral view, one and three-fourths the natural size, shewing the anal orifice, and anal plate with its two adjacent inter-radials. *c.* View of upper surface, twice the natural size, shewing plates in the oral region, the lateral anal orifice, and the pore-plates of pseudambulacral areas.

FIG. 2.



a. *b.* *c.*

Fig. 2. Pentremites Godoni. From Lower Carboniferous rocks of Illinois, U. S. Natural size. *a.* View of base, shewing three large basals, and attachment of stem. *b.* Lateral view, shewing broad, petaloid, pseudambulacral areas, with large transverse striæ, very visible to naked eye. *c.* View of superior surface.

The plates or pieces of which the calyx is composed are: three basals, five radials, six inter-radials, one anal, several anteambulacrals and numerous pseudambulacrals. In Pentremites, in which the lateral opening is completely wanting, there is, of course, no anal plate, and there are only five inter-radial or deltoid plates present. The three basal plates of N. lucina (?) pass outwards from the centre of the topmost joint of the slender pedicle, are very small, irregular in shape, and almost altogether hidden by the stem. Above these are the five dorsally-ridged radial plates slightly forked upon their upper margins for the reception of the lower extremities of the five pseudambulacral areas. These five pseudambulacral fields with the five alternating interambulacral areas form the sides of the calyx. Each pseudambulacral area is much less "petaloid" in outline than the corresponding area of Pentremites, being greatly lengthened and comparatively narrow throughout, and terminate below in a deep pit or depression where the forked radial is raised into an arched eminence. The centre of the area is occupied by a longitudinal furrow, which with its two raised borders forms a long and extremely narrow lancet-plate. Outside the elevated ridges that bound this central furrow on each side is a row of plates or tables numbering about forty, perforated by minute but very visible apertures and known as pore-plates. The remainder or outer portion of the pseudambulacral area is believed to be made up of numerous transverse plates because of its surface shewing very many small yet distinct transverse grooves and elevations. These transversely-striated lateral portions constitute the greater part of the area, and, instead of gradually rising from the pore-plates and central lancet-plate, gradually slope towards the outer edges, so that the whole pseudambulacrum is strongly elevated towards and about the middle line and depressed at its outer margins, as seen in Figure 1, a condition exactly the reverse of that which exists in Pentremites (Fig. 2).

Four of the interambulacral areas consist each of a single, long, narrow, triangular or deltoid plate termed the "inter-radial," its apex reaching the top of the calyx, and its base resting upon two radials beneath. The fifth interambulacral area, however, differs greatly from the others in being much broader (nearly twice as broad), in the possession of a distinct and comparatively large, circular opening near its summit, *two* deltoid or inter-radial plates separated by a long, triangular and externally con

cave plate (Fig. 1 *b*.). The lateral and superior opening has been regarded as the anal aperture; and the long, concave plate, that tapers upwards and is quite prominent at its upper extremity where it forms the inferior boundary of the anus, has been styled the anal plate. The inter-radials of this area also differ in position from those of the other four interambulacral areas, their apices being directed downwards and reaching the radials at the base of the calyx.

On the superior surface of the specimen are to be seen five pairs of little apertures placed in a circle, and usually considered to have been genital in function; whilst in the centre of this circle and also of the summit of the calyx, is an aperture regarded as the mouth, and provided with small protecting plates. Hence, besides the foramina of the poral plates there are twelve openings, viz: the mouth, ten genital openings and the anus.

In comparison with Pentremites it is to be noticed that the radials of Nucleocrinus are much shorter and the inter-radials and pseudambulacra much longer than those of the former; that in Nucleocrinus an anal opening is present in one of the interambulacral regions; an anal plate is also present; and in consequence of the situation of the anal orifice and the anal plate there is an extra inter-radial or deltoid plate in the same area; that the two deltoid plates of this modified area are inverted in position; that the pseudambulacral fields are *convex*, and not concave, possess well marked pore-plates, and rather finely marked transverse grooves.

As the modified interambulacral area is not exhibited in the only figure given of lucina, *i.e.* Fig. 16, Plate 1, of the Fifteenth Report of the Regents of New York State University, it is impossible for me to institute anything like a complete comparison between lucina of New York and the Blastoid under consideration. Still, on comparing the latter with the figure of lucina one cannot fail to observe certain differences between them, in the lancet-plates, the prominently arched radials at the lower ends of the pseudambulacra, and the general shape of the calyx. The bringing to light of other specimens may, in the future, prove, what I strongly suspect, that this is a species quite distinct from lucina, and hitherto undescribed. In such event, this being the first species of Nucleocrinus discovered in this country, I would here propose for it the specific name *Canadensis*.

It is worthy of note that the genus Nucleocrinus in rocks other than American has thus far been altogether unknown to science.

The following are the species heretofore recognized :

1. Nucleocrinus *Verneuili*, Corniferous Formation, Troost, 1841.
2. " *angularis*, Corniferous Formation, Lyon, 1857.
3. " *Conradi*, Upper Helderberg Formation, Hall, 1862.
4. " *elegans*, Hamilton Formation (also said to have been found as low as the Upper Silurian), Conrad, 1842.
5. " *lucina*, Hamilton Formation, Hall, 1862.
6. " *Kirkwoodensis*, Sub-Carboniferous Formation, Shumard, 1863.

NOTE ON THE COMPOSITION OF DAWSONITE.

By B J. Harrington, B.A., Ph.D.

McGill College, Montreal.

In connection with the discoveries of Dawsonite which have been made at Pian Castagnaio in Tuscany,* a few remarks on the composition of this curious mineral may be deemed of interest. It will be remembered that the specimens originally described in 1874 were from joints in a white feldspathic dyke cutting the Trenton limestone near McGill College.† Since 1874 small quantities of the mineral have been observed in the joints of several other dykes in the same neighbourhood, and beautiful specimens have been obtained at the Montreal reservoir, in what is probably a continuation of the dyke near the college. In the latter instance the Dawsonite is associated with calcite, dolomite, pyrite, minute quantities of galena and occasionally of a black substance rich in manganese. In all cases the mineral occurs in more or less fibrous blades, which are often arranged in a radiated manner.

* Two papers on the subject have appeared within the last few months in the Bulletin of the Mineralogical Society of France (IV., 28 and 155), the first, entitled "Sur un nouveau gisement de Dawsonite (hydrocarbonate d'aluminum et de sodium) et sur la formule de ce minéral," by C. Friedel; the second, "Sur le gisement de la Dawsonite de Toscanne," by Maurice Chaper.

† *Can. Nat.* II. vii. 305. "Notes on Dawsonite, a new Carbonate."

It reminds one of tremolite, and in the collection of minerals acquired by McGill College from the late Dr. Holmes of Montreal, there are several specimens of it which he had so marked.

The first specimens of Dawsonite analysed were found to contain between five and six per cent. of lime, and there was no evidence to prove that this was not one of the proper constituents of the mineral. Subsequently, however, it was found that the proportion of lime differed widely in different cases, while the ratio between the other constituents was constant. From this it was inferred that the lime really belonged to intermixed calcite which could not be completely separated. This view is fully confirmed by Friedel's examination of the Dawsonite discovered by M. Maurice Chaper in Tuscany, and the right of the mineral to rank as a good species may now be considered as fully established. Its special interest of course depends upon the fact that it is the only well defined carbonate containing aluminium which has yet been met with in nature.

The Tuscany Dawsonite is stated to occur in minute crevices, both in marl and sandstone, the latter being impregnated with dolomite. Among the minerals associated with it are calcite, dolomite, pyrite, fiorite and cinnabar; and it is said that the miners of the region look upon Dawsonite as a favourable indication in their search for cinnabar. The Tuscany mineral is evidently obtained in a purer condition than ours, and from his analyses Friedel concludes that the composition of the species is represented by Al_2O_3, Na_2O, $2\ CO_2$, $2\ H_2O$ or, as he also puts it, $Al_2\ (CO_2Na)_2\ (OH)_4$.

The following table gives under I. the results of Fridel's analyses; under II and III the original analyses of the mineral from McGill College; and under IV a recent one of that found at the Montreal reservoir. The last it will be seen indicates the presence of a large proportion of calcite :—

	I	II	III	IV
Carbon dioxide......	29.59	29.88	30.72	32 23
Alumina............	35.89	32.84	32.68	24.71
Soda	19.13	20.20	20.17	15.64
Water	12.00	11.91	(10.33)	9.06
Lime..............	0.42	5.95	5.65	16.85
Magnesia	1.39	tr.	0.45	tr.
Potash	....	0.38	....	....
Manganese dioxide...	....	....	....	0.23
Silica	....	0.40	....	0.84
	98.42	101.56	100.00	99.56

If from the above analyses we deduct the substances which may justly be regarded as impurities, including lime and magnesia in the form of carbonates, and then calculate the normal constituents for one hundred parts, it will be seen that the results agree well with the formula $Na_2 [Al_2] C_2O_8 + 2H_2O$:

	I	II	III	IV	FORMULA.
Carbon dioxide*	29.27	27.96	29.06	27.78	30.49
Alumina...........	37.88	36.42	36.70	36.12	35.55
Soda..............	20.19	22.41	22.65	22.86	21.48
Water	12.66	13.21	11.59	13.24	12.47

It has also been suggested that the formula may be written $3(Na_2CO_3) + (Al_2C_3O_9) + 2(H_6[Al_2]O_6)$.†

According to Friedel, the Tuscany Dawsonite when heated to 180° C. loses nothing but a little hygrometric water. Like the Canadian mineral it gives up both its "carbonic acid" and water at a red heat. The calcined residue also dissolves easily in hydrochloric acid. Neither the hardness nor the specific gravity of the European variety has been ascertained. For the Canadian mineral the original determinations were, H = 3, G = 2.40.

* The atomic ratios for I and II are as follows:

C	.665	.636	2
$[Al_2]$	.369	.355	1
Na	.651	.723	2
O	2.764	2.696	8
$\left.\begin{matrix}H_2\\O\end{matrix}\right\}$	.703	.734	2

† Am. Jour. Sci. III. xxii. 157.

RESUMÉ ON WATER ANALYSIS: NEW METHODS AND RECENT RESULTS.

By J. Baker Edwards, Ph.D., F. C. S.

Public Analyst, Montreal.

Considering the many discrepancies of water analysis, the Society of Public Analysts of Great Britain have done good service to social science by co-operating with Mr. G. W. Wigner, one of its Secretaries and one of the editors of its organ "The Analyst," in discussing during the present year:

1. The Methods of Water Analysis.
2. Mode of Statement of Results.
3. Their Comparative Valuation.

Moreover, by the publication of monthly analyses of the "Public Water Supplies of Great Britain," they have conferred a benefit on the public. Mr. Wigner has long been a laborious "Water Analyst," and from his great experience on "Sea Side Waters," his opinion is entitled to considerable weight. As a result of his labours a Committee has been appointed by the Society of Public Analysts, which has drawn up and published a code of "Instructions for Water Analysis," in order to enable Analysts generally to co-operate, by adopting an uniform method of analysis and of the mode in which results shall be stated. It has still under consideration the mode of valuation of the relative impurities in potable waters submitted to the Soeiety by Mr. Wigner in June last, which has subsequently been very generally approved. Comparative results having been thus rendered possible, a large number of English chemists have accepted the task of monthly water analysis in various districts, and these have been grouped together by Mr. Wigner in the recent September and October Nos. of "The Analyst," showing the average values of the impurities from January to June of the present year, and the valuations for July, August and September, severally, of 65 different water supplies in Great Britain, representing an enormous amount of exact and laborious work, which is much enhanced in value by this mode of bringing into comparative

review differences which, without *uniformity of method, of statement, and of valuation*, would have no scientific interest whatever. Although the methods of research are *numerous* and *critical*, the Analysts of the Continent will, I feel sure, welcome anything like agreement on so vexed a question as water analysis, and will welcome these tabulated results, even if subsequent experience should lead to slight modifications of either *the methods or the valuations*.

Having lately had occasion to analyse for the Department of Public Works several samples of Ottawa water, I have carefully followed these methods and valuations, and I find much satisfaction in being thus enabled to classify them with British results so recently published, and from my own experience recommend to brother analysts in Canada and the United States the adoption of this general method, so that future tabulations of comparative values may include the whole of the waters of this Continent.

The following statement of results in the case of the Ottawa water supply will indicate the general method of analysis and mode of statement. For details the reader is referred to the elaborate "Code of Instructions" published in the June, July, and August numbers of "The Analyst," and also subsequently published in pamphlet form by the Society of Public Analysts.

Result of analysis of Ottawa water supply, taken Sept. 7th, 1881, by Messrs. Keefer, Lesage and Arnoldi.

	1. Color in 2 feet column	light yellow.
	2. Odor at 100 F.°	slightly peaty.
*	3. Chlorine as Chlorides	·4
	4. Phosphoric acid	none.
	5. Nitrates and nitrites	none.
	6. Ammonia free	·0050
	7. Albumenoid Ammonia	·0010
	8. Oxygen absorbed at 80 F. in 15 minutes.	·0040
	9. Hardness by Clarke's test	3·5°
†	10. Solids in solution	4.8
‡	11. Solids in suspension	4·2
§	12. Microcosms	chiefly vegetable.

The first mode of calculating the valuation of results is by fixing values to each of these impurities. Pure distilled water

* Quantities expressed in grains for Imperial gallon of 70,000 grs.
† Containing Alkaline Silicates.
‡ Chiefly Siliceous fragments.
§ Chiefly Diatoms and Sponge spicules and Algæ.

is taken as the standard of absolute purity—not taken for granted but ascertained by experiment. Variations from purity are assessed according to the following plan :

1. Appearance, blue clear 0 ; pale brown 1 ; pale yellow and green 2 ; dark yellow and dark green 4
2. Suspended matters, traces 1 ; heavy traces 2 ; turbidity 4
3. For odor, vegetable 1—2 ; animal 4
4. Chlorine ·5 gr. per gallon 1
5. Phosphoric acid, traces 2 ; heavy traces 4 to 8
6. Nitrogen as Nitrates, &c., ... ·100 gr. per gal. = 1
7. Ammonia..................... ·005 " = 1
8. Albumenoid .... ·001 " = 1
9. Oxygen absorbed in 15 minutes. ·002 " = 1
10. Do. " in 4 hours.... ·010 " = 1
11. Hardness before and after boiling 5° = 1
12. Total solid matter 5 grs. per gal. = 1
13. Heavy metals, traces................ = 6
    Do. heavy traces.......... = 12
14. Vegetable débris.................... = 4 to 8
15. Diatoms and Bacteria .... = 6 to 12
16. Hairs and animal débris............. = 10 to 20

This scale of valuation allows a considerable latitude for the exercise of judgment on the part of the Analyst and of allowance for exceptional cases. On this scale 10 is assumed to be the maximum for any one of these impurities, and if any single impurity exceeds 10 the excess is doubled and included in the addition. The classification of waters as more or less pure, after such valuation, is more difficult to agree upon, and will not be accepted without considerable discussion and probably some differences of opinion. Still the valuation of the results already obtained are of the utmost value, and will be increased by the continued publication of monthly returns to the year's end.

At present Mr. Wigner recommends the following grouping of waters :

Waters showing 15 or under are of exceptional purity.
" above 15 and under 40....1st class.
" " 40 " 65....2nd class.
" " 65 " 90....3rd class.
" " 100.....condemned as unfit for use.

Taking now the results obtained from the analysis of the Ottawa water, I value as follows :

1.	Color	1
2.	Odor	·5
3.	Chlorine	1·0
4.	Phosphates	none.
5.	Nitrates	none.
6.	Ammonia	·5
7.	Albumenoid	1·0
8.	Oxygen absorbed	2·0
9.	Hardness	1·0
10.	Solids in solution	1·0
11.	Solids in suspension	1·0
12.	Microcosms	1·0
		10·0

This water, therefore, stands very high on the British scale of purity. Some other examples of Ottawa water ranged as high as 12 for impurity but 11 may be taken as the mean value.

Now by the publication of these monthly returns based upon the same methods, I am enabled to give a comparative view of a series of English water supplies examined in the same month of September last. Thus—all exceptionally pure:

Rochdale valuation	= 9
Warwick	= 10
Canterbury	= 12
Swansea and Wolverhampton	= 15

First class:

Bolton	= 17
Shrewsbury	= 19
Brighton and Salford	= 21
Exeter and Leicester	= 23
Bury and Edinbro'	= 24
Portsmouth	= 27
Plymouth	= 28
Birmingham	= 29
Bristol and Whitehaven	= 30
London supplies	21 to 39

Second class:

Rugby	= 46
Liverpool	= 47
Darlington	= 50
Newcastle-on-Tyne	= 68
Kings and Lynn	= 110 (condemned.)

Ottawa supply 10 to 12

It would thus appear that Ottawa water ranks very high in purity as compared with the average water supplies of Great Britain even after filtration, and that, while this mode of additional precaution is open to the private consumer and is of the most serious importance in the prevention of disease, it is an open question as to how this can be best conducted in this country so as to be of general advantage, and it appears to me that (considering the exigencies in case of fire, the variability of climate, the severity of winter, and other considerations incidental to this country.) for the water impurities, present filtration is the only remedy, and household filtration the only practical remedy. I have therefore to recommend a plan of general household filtration which should be generally adopted and made compulsory on all water companies, in which water should be filtered from the main supply into houses or tenements or streets, and that taxes should be imposed for the use of filters as for the use of gas meters, added to the consumer's account on a pro rata basis. This project, I think, would prove effectual, and I hope may be found practical, and thus remove one of the many public grievances from the municipal shoulders of the corporate bodies of Canada.

On referring to the water analyses which I reported on the Montreal supply in 1879, and applying to these results the table of valuation, I find that notwithstanding the including of matters in suspension, Montreal water stands high by comparison. Thus,

March 1st,	standard of impurity	11·5
April 21st,	" "	16·5
July 30th,	" "	15·5

Montreal water would therefore be exceptionally pure under such a system of filtration as I have suggested. That this is not utopian is, I think, proved by the fact that several modes of filtration have been patented which have considerable merit and one or other of which might be adapted to larger or small rates of filtration with satisfactory results.

That a simple flannel bag or felt filter is capable of removing a large quantity of the most objectionable kind of floating animal and vegetable matter is shown by the quantity removed in the flannel bag now exhibited, which has been in use for two days only over the supply pipe of the Parliament buildings at Ottawa, and which has removed upwards of four ounces of débris, river mud and vegetable matter, more than a score of snails, besides

water beetles, worms and other not very minute animals. This is of course but a very partial filtration, but it is simple and within the reach of all. The models of filters on a large scale capable of effectually filtering very large supplies, I now exhibit to the Society.

No. 1. Howell's Patent—filters by capillary attraction through hempen cloths; it is built in sections, so that it can easily be taken asunder and cleansed. As a water-filter animal charcoal is placed between the sections, and such a filter would only require cleansing once a year or so.

No. 2. Foley's Patent, is manufactured by Robert Mitchell & Co. of this city. It contains sand and animal charcoal and is exceedingly effective. Under the ordinary pressure it filters the whole water supply of a house or public building, and is easily cleansed by reversing the currents of water, without disturbing the packing.

No. 3. Crocket's Patent, is designed for large quantities, such as district supplies, or "Station Filters." It is also cleansed by reversing the supply, and is an effective filter, applicable to public purposes and large volumes of water.

These designs show that there exist no insuperable difficulties in the filtration of water on the large scale in Canada; and such filtration would remove one-half of the solid matter, and therefore would render the water supply *twice as pure* as it is at present.

ON SOME FOSSIL FISHES, CRUSTACEA & MOLLUSCA FROM THE DEVONIAN ROCKS AT CAMPBELLTON, N.B., WITH DESCRIPTIONS OF FIVE NEW SPECIES.

By J. F. Whiteaves.

During the past summer Mr. R. W. Ells has been engaged in a continuation of his explorations in New Brunswick and on the north shore of the Baie des Chaleurs, on behalf of the Geological Survey of Canada, while Mr. A. H. Foord was occupied in making additional collections of the fossil fishes of Scaumenac Bay for the museum of the same institution. Towards the latter end of June Mr. Ells discovered remains of fishes, which he correctly supposed to belong to the genus *Cephalaspis*, in argillaceous and brecciated limestones * on the south bank of the Restigouche river, about half a mile above Campbellton. At the first opportunity this discovery was communicated to Mr. Foord, who at once visited the locality and devoted a week to a thorough examination of the fish-bearing beds. From these deposits he obtained a large number of specimens of *Cephalaspis*, a fine series of cranial shields and detached plates of a species of *Coccosteus*, fin spines of *Ctenacanthus* and *Homacanthus*, fish teeth, entomostraca, fragments of a large *Pterygotus*, a *Spirorbis*, and two small species of gasteropoda.

From the same rocks Principal Dawson has since collected a number of fossil fishes, &c., which he has kindly allowed the writer to examine and study. This collection, however, has not afforded any additional species to those already found by Mr. Foord, although some of the specimens in it, and especially two or three of the shells of gasteropods, are in an unusually fine state of preservation.

Before these discoveries were made, the only fossils that had been found in the Devonian rocks at Campbellton were plants, and on the evidence afforded by them Principal Dawson has concluded, first, that these deposits are probably of the same age as

* The rock is for the most part a dolomitic agglomerate, passing upwards into coarse shales, and associated with felsitic and trappean beds.

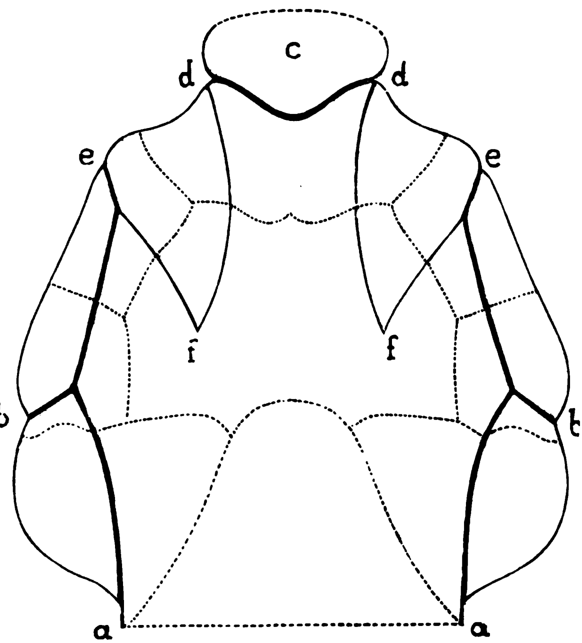
the Lower Gaspé sandstones, and secondly, that the former as well as the latter belong to a lower horizon in the Devonian system than the fish-bearing beds of Scaumenac Bay. The correctness of both of these conclusions seems to be corroborated by what is now known of the fauna of the Campbellton limestones and breccias, which are found to hold entomostraca, together with representatives of the genera *Coccosteus*, *Cephalaspis*, *Ctenacanthus*, *Pterygotus* and *Spirorbis* in common with the Gaspé sandstones. In Gaspé Bay these sandstones are known to rest directly and conformably upon limestones, the two lower divisions of which are stated by Mr. Billings to be representatives of the Lower Helderberg group, while the two upper have been regarded, by the same authority, as "nearly of the age of the Oriskany sandstone." From this statement and from the sections published in the Geology of Canada, it would appear that the greater part of the Gaspé sandstones occupy a very low position in the Devonian, but that they are separated from the extreme base of that formation by a thickness of at least 800 feet of limestone. At Scaumenac Bay, on the other hand, the fish-bearing beds are immediately overlaid by the sandstones and conglomerates of the Bonaventure formation of the Lower Carboniferous, and of the seven genera of fishes now known to occur in the Devonian rocks at this locality, not a single one of them has yet been found in the Gaspé sandstones or at Campbellton.

The following descriptions embrace the whole of the species collected at Campbellton by Mr. Foord, with the exception of the *Spirorbis*, entomostraca and some fin spines and fish teeth which have yet to be studied.

Fishes.

Coccosteus Acadicus. Sp. Nov.

Cranial shield. Flattened or depressed centrally and a little in advance of the centre, but always rising into a broad, low prominence on the median line at a short distance from the posterior margin: sides somewhat sloping. General outline that of an ovoid truncated at its broadest extremity, the truncation being posterior, the length and breadth nearly equal, and the greatest breadth behind the mid-length. Postero-lateral angles (*a.a.*) somewhat produced: lateral margins most convex posteriorly, slightly concave anteriorly, and with a small but distinct notch (*b*) a little behind the middle. When the rostral plate (*c*) is



Outline of a specimen of the cranial shield of *C. Acadicus*, shewing the rostral plate (*c*) in situ. Some of the superficial grooves restored from other specimens. Natural size.

absent, which is almost invariably the case, the anterior margin is concavely emarginate in the centre, the emargination being broad, transverse and bounded on each side by an obtusely angular projection (*d*). On the outer side of each of these projections there is an obliquely and shallowly concave, lateral emargination. In one specimen only (that from which the accompanying drawing was made) the rostral plate (*c*) fits into and completely fills up the central emargination of the front margin of the shield. This plate, which is nearly twice as broad as long, projects beyond the front margin of the shield, its two sides are narrowly rounded, but its anterior margin is broken. Test very thin. Sculpture consisting of numerous small, conical tubercles; which are smooth at their summits and marked with fine radiating grooves below. On some of the bony plates of the shield the tubercles are isolated and scattered, but in others they are arranged very distinctly in concentric lines separated by continuous furrows. Besides the

tubercles, the surface is marked by certain superficial grooves, which are represented in the wood-cut by unbroken lines. The general direction of most of these grooves is longitudinal, and the most strongly marked are those which run from the antero-lateral (*e. e.*) to the postero-lateral angles (*a. a.*) and which are nearly parallel to the sides of the shield. Sutures scarcely perceptible: their apparent outlines being indicated in the figure by dotted lines.

Post-dorsomedian plate. Convex along the median line but highest in the centre, from which point there is a downward slope in every direction, the lateral slopes being most abrupt. Outline oblong but narrowing posteriorly so as to form a short beak. Anterior end somewhat rounded, sides parallel for more than two-thirds of their length, then attenuating rapidly into a point with obliquely concave sides. Maximum breadth equal to about one-third the entire length; apex of the beaked extremity curved slightly upwards. Tubercles arranged concentrically but not in distinct rows, those in the centre being the smallest, and those near the circumference being both distant and of comparatively large size.

Ventromedian plate. Flat; subrhomboidal, but with all the sides unequal and the margins of two of them (the right anteriorly and the left posteriorly) shallowly concave. Posterior extremity rather more produced than the anterior; length about one-third greater than the breadth. Tubercles arranged in distinct rows on three sides, but not on the left side of the posterior half, where they are nearly all isolated, those towards the centre being comparatively large and those near the centre very minute and densely crowded.

Pre-ventrolateral plates. Flat; longitudinally subreniform, a little longer than broad; outer margin concavely emarginate and inflected. Tubercles isolated, crowded and arranged obscurely in concentric, subparallel lines.

More than twenty well preserved and tolerably perfect specimens of the central shield have been collected, besides numerous fragments, but the suborbital plate is invariably absent, and the rostral plate is only preserved in place in one or two instances. The whole of these shields, too, appear to have been flattened by pressure, and if so, they may once have been longer in proportion to their breadth than they now are, and the anterior sinus into which the rostral plate fits, may have been narrower and deeper.

The few detached plates yet found are rarely perfect, though the sculpture of their outer surface is always beautifully shewn.

In some respects the Campbellton *Coccosteus* very closely resembles the *C. cuspidatus* of Agassiz, but in others there are such marked differences between the two forms that it is thought most prudent, for the present, to distinguish the Canadian species by a local name. No detailed description of *C. cuspidatus* has ever been published, and the illustrations that give the best idea of its characters are the figures on plate 3 of the "Old Red Sandstone." Assuming that these figures are essentially correct. the shape of the post-dorsomedian plate of the Campbellton *Coccosteus* (which Agassiz, who calls it the dorsal plate, regards as offering one of the best specific characters) and that of the diamond shaped ventro-median are almost exactly similar to those of *C. cuspidatus*. But on the other hand, in many of the plates of *C. Acadicus*, and especially in some which have not been separately described on account of the uncertainty of their homologies, but which are supposed to be isolated dorso-median plates of exceptionally large individuals, the tubercles are arranged in very distinct concentric lines, with continuous and comparatively broad grooves or spaces between them; an arrangement not indicated at all, or at most very obscurely, in the figures of *C. cuspidatus*. Again, the superficial grooves on the cranial shield of *C. Acadicus* are much more like those of *C. decipiens* as represented in a wood-cut in the "Foot Prints of the Creator," (third edition, figure 11) than they are like those in the figure of *C. cuspidatus* in the "Old Red Sandstone." In the *C. Acadicus* the most conspicuous of these grooves are constantly those which run from *a* to *e* on the accompanying diagram, and from the centre of each of these lines to the lateral notches at *b*. *b*. Making allowances for distortion, precisely similar grooves are to be seen in Miller's woodcut of the "cranial buckler" of *C. decipiens*, but they are entirely absent in his figure of the cranial shield of *C. cuspidatus*. Further, in the Campbellton *Coccosteus* other superficial grooves run from *e*. *e*. and *d*. *d*. to *f*. *f*. in such a way as to inclose a triangular space on either side, with a wide space between their inverted apices at *f*. *f*. This again, is just the arrangement in the "cranial buckler" of *C. decipiens*, whereas in *C. cuspidatus* the apices of the two triangles are not separated by a space but connected by a curved, transverse groove. It would seem, therefore, that the *C. Acadicus* may be distinguished from *C. decipiens*

by the different shape of its post-dorsomedian plate, from *C. cuspidatus* by the different arrangement of the grooves on the outer surface of its cranial shield, and from both by the peculiar sculpture of its bony plates.

Cephalaspis Campbelltonensis. Sp. Nov.

Head shield (the only part known) large, somewhat pointed in front, obliquely rounded at the sides anteriorly, and produced behind into moderately elongated, slightly incurved cornua. Maximum breadth about seven inches. Orbits varying in outline from nearly circular to longitudinally broad ovate, sub-central, approximated, placed at distances from each other varying in different specimens from once to thrice the diameter of the orbit itself. Antorbital prominences rounded-conical; interorbital prominence also conical but somewhat elongated longitudinally; postorbital valley bounded by two narrow raised ridges, each of which starts from a prominence immediately behind the orbit: about halfway between the orbits and the posterior margin these ridges coalesce so as to form a single, broad and prominent but somewhat obscurely defined, posterior ridge.

Outer surface, which is very rarely preserved, polished and almost smooth to the naked eye. When examined under a lens it is seen to be minutely and densely pitted, the pits being very irregular in their shape, size and method of arrangement. Where the enamel is removed the surface is divided into numerous well marked polygonal areas.

Large fragments of the head-shield of this species are abundant in the Campbellton breccia, but the most perfect specimens yet obtained do not shew the outline of the posterior margin of the shield at all clearly. The orbits and the prominences and depressions in the central portion of the shield are often well defined, but the specimens are always crushed and nearly always exfoliated. Portions of the true outer layer of the test have been seen only on the central portion of the outer margin of the sides of one large fragment, and on the extremities of the cornua in two or three other specimens.

The genus *Cephalaspis* has been divided by E. Ray Lankester into three subgenera, viz., *Eucephalaspis*, *Hemicyclaspis* and *Zenaspis*, but as *Hemicyclaspis* is stated to be devoid of cornua it is clear that the *C. Campbelltonensis* cannot belong to this subgenus. Of the two which remain, *Eucephalaspis* and *Zenas-*

pis have precisely similar head shields, but the body of *Zenaspis* has a dorsal scute placed immediately behind the posterior spine. In the absence of any knowledge of the body of the Campbellton species, therefore, it is uncertain to which of these two subgenera it should be referred.

Including the *C. Dawsoni* of Lankester, from Gaspé, all the specimens of *Cephalaspis* hitherto described are said to be characterized by a surface ornamented by raised tubercles, so that the *C. Campbelltonensis* may be readily distinguished by its minutely pitted sculpture. In general outline the head shield of the present species appears to be very much like that of the *Eucephalaspis Powriei* from the Old Red Sandstone of Forfarshire.

Ctenacanthus latispinosus. Sp. Nov.

Compare *C. ornatus*, Agassiz. Recherches sur les Poissons Fossiles, Vol. 3, page 12, Table 2, figure 1.

Fin spines small (as compared with those of most of the other species of the genus) compressed laterally : either elongated, slightly curved and tapering rapidly from a rather broad base to an obtuse point,—or comparatively short, straight and triangular. Posterior margin somewhat concave, and bearing on its upper portion certainly one row and presumably two rows of short, conical hooklets, which curve obliquely downwards. Anterior margin thin, straight or gently convex, and unarmed. Surface marked on each side by from 15 to 20 longitudinal ribs, which swell out at regular intervals, of about one-third of a line apart, into subangular, equidistant nodes.

Length of the largest spine collected, about two inches and a half: maximum breadth of the same at the base, about three quarters of an inch.

The few spines of this species collected by Mr. Foord are all partly imbedded in the matrix, so that the grooving of the posterior margin is hidden from view, and only one row of hooklets is exposed.

Homacanthus. Sp. Undt.

Compare *H. arcuatus*, Agassiz. Poissons fossiles du Vieux Grès Rouge, page 113, Table 33, figures 1-3.

Fin spine rather large (for a *Homacanthus*) compressed laterally, distinctly curved, slender, elongated and tapering very gradually from a narrow base to an apparently obtuse point. Upper

portion of the posterior margin armed with one or more rows of conical hooklets, which curve obliquely downwards. Surface ornamented by longitudinal ribs, with fine oblique striations.

Length about 17 lines, breadth at base about 3 lines.

Only one imperfect and badly preserved specimen was obtained, one side of which is buried in the matrix. It differs from the spines of *Ctenacanthus latispinosus* in its more slender proportions, more arcuate form, and apparently also in its surface ornamentation. As far as can be ascertained at present this spine appears to be very similar to the *H. arcuatus* of Agassiz, in almost every respect but that of size, the Campbellton species being much the larger of the two.

Crustacea.

Pterygotus. Sp. Undet.

The occurrence of this genus at Campbellton is indicated by a fragment shewing the characteristic sculpture of semi-circular plicæ,—and by a single ramus of the chela of an antenna, which must have belonged to a very large species. This ramus, which is not quite perfect at either extremity, is about two inches and a quarter in length, and nearly half an inch in breadth at its largest end. It bears on its inner margin four or five unequal-sized, but comparatively large teeth, one of which is of much greater dimensions than the rest,—with a number of smaller ones between them. All the teeth are compressed and longitudinally striated: most of them are ovate-lanceolate in outline, the basal portion being slightly constricted,—but some of the small ones are simply conical.

Mollusca.

Cyclora valvatiformis. Sp. Nov.

Shell very small, depressed turbinate, broader than high, spire much depressed: whorls three and a half, ventricose, rounded, increasing very rapidly in size, so that the greater part of the shell is formed by the last one, sutures deep; umbilicus between one-third and one-fourth of the diameter of the body whorl, deep in the centre and rounded at the margin. Mouth nearly circular but slightly angular posteriorly, next to the suture; lip thin and somewhat spreading. Surface nearly smooth, marked only by a few faint striæ of growth.

This species was found in great abundance both by Mr. Foord and Principal Dawson, the most perfect specimens being those which were obtained from weathered surfaces. The resemblance of this little shell to the *Cyclora minuta* of Hall, from the Hudson River Group of Cincinnati, is certainly very close. The only differences that can be noticed between them at present, judging by Meek's detailed descriptions of Hall's species, are that the aperture of *C. valvatiformis* is slightly subangular behind and the lip somewhat expanded, whereas the phrases used to describe the corresponding parts of the shell of *C. minuta* are simply—"aperture circular, lip thin." It is scarcely likely, however, that a shell which occurs associated with remains of *Coccosteus* and *Cephalaspis*, on the same small hand specimens of rock, is identical with a species from such a different geological horizon as the Hudson River Group.

Cyclora turbinata. Sp. Nov.

Shell very small, turbinate or turbinate-conical, about one-third higher than broad, spire elevated: whorls four or four and a half, ventricose, rounded, increasing rather slowly in size, sutures rather deep: body whorl also rounded, base imperforate, aperture sub-circular, slightly angular behind: lip thin and somewhat spreading.

Length three lines, maximum breadth two lines.

Not more than about half a dozen specimens of this little shell have been collected. The species is invariably found associated with the *C. valvatiformis*, from which it differs in its much more elevated spire and closed umbilicus. Like *C. valvatiformis*, the present species is somewhat similar to one of the diminutive gasteropoda of the Hudson River Group of Ohio, the *Cyclora parvula* of Hall, but the body whorl of the latter shell is described as subangular, and its umbilicus as not quite closed.

NOTE ON A FERN ASSOCIATED WITH *PLATEPHEMERA ANTIQUA*, SCUDDER.

By J. W. Dawson, LL.D., F.R.S.

The oldest remains of insects known to geologists, those of the Erian (Devonian) shales of St. John, New Brunswick, occur in beds rich in plant remains. It was indeed solely by means of the extensive quarrying operations carried on by Messrs. Hartt and Matthew in these beds in search of fossil plants, that the insect remains were discovered. In less thoroughly explored beds, fossils so rare and so obscure could not have been found. It is natural therefore that fossil plants should occur on the same slabs with the insects. On one of these, holding a fragment of the wing of *Platephemera antiqua*, there appears a considerable portion of a frond of *Pecopteris* (*Aspidites*) *serrulata*, Hartt, a common species in these beds, and also a small fragment of a leaf of the still more common *Cordaites Robbii*. It appears that Dr. Geinitz of Dresden saw this specimen in 1866, and not being at that time familiar with the ferns of the Devonian of New Brunswick, very naturally supposed that the frond was that of the closely allied *P. plumosa* of Brongniart, and on this ground he was induced to hint a suspicion that the specimen was of Carboniferous age. Dr. Scudder referred to this opinion of Geinitz in his paper on Devonian insects in the Geological Magazine, Vol. V.; and gave reasons sustaining the Devonian age of both fern and insect. I did not think it necessary to refer publicly to the matter, but took occasion to explain the true state of the case in a private letter to Geinitz; and in my report on the Devonian plants of Canada I quoted Hartt's description in full, and noticed the distinctness of his species from *P. plumosa*.

I find, however, that this doubt has been revived by Dr. Hagen in a paper on Devonian insects in the Bulletin of the Museum of Comparative Zoology for the present year (Vol. viii. No. 14). Dr. Hagen does not profess to be an authority in fossil plants, but fortifies his statements by a letter from Mr. Lesquereux, which does not however touch the question at issue, as he does not appear to have compared the specimen or Hartt's species with

P. plumosa; and though he insinuates a doubt as to the validity of some of my Devonian species, even this does not apply, since the species in question was carefully described by the late Prof. Hartt, and accepted by me after study of his material, which included several very considerable portions of well-preserved fronds.

Though doubts and suspicions thus cast on work carefully and exhaustively done, in so far as material exists, should not seriously affect the minds of naturalists, I have thought it desirable to set the matter at rest, as far as possible; and have therefore, through the kindness of Dr. Scudder and the Curator of the Boston Society of Natural History, obtained access to the original specimen, and would now state the actual facts.

The fern on the specimen in question (No. 8496 of the Boston Society's collection) is undoubtedly *Pecopteris serrulata* of Hartt, and exhibits in a tolerable state of preservation six secondary pinnae of one side of a primary pinna of the species. To a hasty observer, supposing the specimen to be a piece of Carboniferous shale, it would be natural to refer the fern to *P. plumosa* of Brongniart or to *Aspidites silesiacus* of Goeppert, which it perhaps more closely resembles; and since its fructification is still unknown, it may quite as likely belong to the group or sub-genus *Aspidites* in which Goeppert and Schimper place *P. silesiaca*, as to that of *Cyathites* in which Schimper places *P. plumosa*.

The distinctive characters indicated by Hartt are principally the form and insertion of the pinnæ, the slender crenulate revolute, lanceolate pinnules, and the simple veinlets. Perhaps the most obvious characteristic is the peculiarly elongated acuminate points of the primary and secondary pinnæ, in which this species seems to differ from all its near allies. In the specimen in question, though only a portion of one side of a primary pinna is seen, and its characteristic elongate termination is absent, yet one of the secondary pinnæ shows this character very well, and the simple veins and crenate revolute margins may be made out with a lens in a good light. I do not think that any palæobotanist, in view of these characters, would decide to identify this fern with *P. plumosa*, unless indeed he were of opinion that the whole group to which that species belongs should constitute one broad specific type extending from the Devonian to the Permian, a view to which I should have no objection, provided sufficient connecting links can be found.

It is farther to be observed that this fern occurs with a group of species which I have shown to be distinct not only from those of the Coal Formation but from those of the Millstone Grit and those of the Lower Carboniferous Coal-measures or Horton series (sub-Carboniferous of some American geologists), which sub-floras are well developed in the Acadian provinces, and overlie stratigraphically the beds holding the fern which is the subject of this note and its associated fossils.

I may add here Hartt's description of the plant and my note on it, from my Report of 1870 :—

"PECOPTERIS (ASPIDITES ?) SERRULATA, Hartt.—(Pl. XVIII, Figs. 207 to 209.)—Acad. Geol. p. 553, Fig. 92.—M.D., St. John, New Brunswiek."

"Tripinnate; pinna short, alternate, close or open, lanceolate, very oblique, situated on a rather slender, rounded, sub-flexuose rachis; pinnules small, linear lanceolate, crenulate, revolute, moderately acute, oblique, sessile, decurrent, widest at the base, open, separated from one another by a space equal to the width of a pinnule, slightly arched towards the point of pinna; longest at base of pinna, decreasing thence gradually to the apex; terminal pinnule elongated. Median nerve entering the pinnule very obliquely, flexuous, running to the apex. Nervules very few, oblique, simple, and some-what rarely forking at the margin."

"Numerous additional specimens of this species confirm Prof. Hartt's determination of its distinctness from *P. plumosa*, Brongt. It perhaps more strongly resembles Goeppert's *P. Silesiaca* ; but this last has broader und more closely arranged pinnules decur-rent on the petiole. It may be taken as a Devonian representa-tive of the delicate Pecopterids of which the species above named are Carboniferous types. Mr. Hartt's specimens enable me to represent its habit of growth. Schimper quotes under this name a Carboniferous species of Lesquereux. But Lesquereux's species is *Alethopteris serrula*." (This was subsequently corrected by Schimper in the Supplement to his Palæontologie Vegetale.)

NATURAL HISTORY SOCIETY PROCEEDINGS.

Session 1880–81.

The last regular monthly meeting for the session 1880–81 was held on Monday evening, April 25th. Principal Dawson occupied the chair. The minutes of last meeting were read and sustained.

The Council presented a report recommending the transfer to Mr. Wolferstan Thomas of the mitoyenne wall on the north side of the Society's building and the narrow strip of land adjoining, so as to enable Mr. Thomas to connect his buildings in course of erection with the Museum.

A motion was made by Mr. G. L. Marler, seconded by Mr. W. Muir, and carried unanimously, approving of the report, and authorizing Mr. Marler to sign the agreement with Mr. Thomas.

Mr. Muir, the cabinet-keeper, stated and exhibited what additions had been made to the museum, namly, a prairie wolf and a remarkable specimen of the hare by donation; a Canadian lynx and a number of birds by purchase. The thanks of the Society were voted to the donors.

The Secretary read extracts from a lengthy paper by Mr. R. Chalmers, of New Brunswick, on the Glacial Phenomena of Baie des Chaleurs.

Dr. Dawson said the facts stated in the paper were a large contribution to our knowledge of that region, but he intimated that he did not quite agree with some of the author's theories.

Mr. W. Muir gave a detailed explanation of a new and improved method he had discovered of obtaining oblique light for the microscope. He said:

Not having an instrument with a swinging substage, my substage having only rack and rotary movement, and not satisfied with the working of the spot lens (as usually furnished) and Wenham's paraboloid, I was led to experiment with various means of oblique illumination; among others placing the Amici

prism underneath, and to one side of the stage. I was surprised at the brilliancy of the effect produced, and concluded that if so brilliant an effect were produced by oblique rays from one point only, much more brilliant would be the effect if I could procure a condenser that would throw a complete circle of oblique rays on the object. I took my small bull's eye condenser of 1$\frac{3}{8}$ in. diameter and 1 in. focus, placed on it a disk $\frac{5}{8}$ in. diameter, capable of being raised or lowered, and by means of an adapter placed it in my substage, using the flat mirror and either the 1 inch or 2 inch objective. I obtained an effect (particularly with the inch objective) which surpassed my most sanguine expectations. In transparent tissues such as the maple leaf insect, there were clearly revealed lines and structure that could not be seen otherwise, and in insects partially transparent, a perfect *flood* of oblique light with a dark ground was thrown on the structure, producing marvellous effect and giving wonderful clearness of definition to the finest lines. With my 1 inch objective I could see, on the two minute lancets of the mosquito (having the saws at their ends) running from root to the saw a beautiful fringe of exceedingly minute, long hairs, hooked at the ends, sharp and well defined, having a dia. $\frac{1}{30000}$ in. or .846659*u*. and set 11,000 to the inch, which owing to their transparency I had never seen before. The markings and rounded structure of *Pleurasigma angulatum* are seen with the inch objective and binocular. By raising the disk the field is darkened, and by different focussing of the condenser, various effects are produced. With this mode of illumination, it is necessary to see that the flat mirror is in the axis of the instrument.

I placed on the centre of the disk a projecting pin which enabled me to put and retain on it different plates or diaphragms shutting out whatever portions of the circle of light desired. As a condenser for high powers the apparatus described is unsurpassed. I intend trying a condenser 1$\frac{1}{4}$ in. dia., $\frac{5}{8}$ in. focus with $\frac{1}{2}$ in. spot, in the hope that with still more oblique rays, even a more brilliant effect will be attained.

After some remarks from Dr. Baker Edwards, those present adjourned to the library, where a number of microscopes were exhibited by members of the Microscopical Club, and by Mr. Muir who showed the excellent results that could be obtained by his method of illumination.

ANNUAL MEETING.

The Annual Meeting for the Session 1880–81 was held on Wednesday evening, May 18th, 1881. The President, Principal Dawson, occupied the chair. The minutes of the last annual meeting were read and sustained.

Having presented Major Latour with the Society's Bronze Medal for his many important services to the Society, the President delivered his

ANNUAL ADDRESS,

in the course of which he said that the year just closed had been distinguished more for the improvements made in the Museum of the Society and in its financial position than for extent of scientific work, though the latter had not been inconsiderable. The Society had sustained a great loss by the removal to Ottawa of several very efficient members connected with the Geological Survey and it was the more important on this account that it should endeavour to increase its membership and more particularly to attach to itself young men who take an interest in science. He referred to the discoveries resulting from the labors of Mr. Ells, Mr. Whiteaves, Mr. Foord and Mr. Weston in the upper part of Baie des Chaleurs. The remarkable association in that locality, within a very limited space, of Upper Silurian, Devonian and Lower Carboniferous rocks, was in itself of much interest, and the remarkable group of Upper Devonian fishes worked out by Mr. Whiteaves, and described by him at one of their meetings, completed a link of connection between the fossils of this country and of Great Britain. The plant remains of this locality also, connecting as they did the Gaspé sandstones with the Perry beds and with the Cattskill series of New York, were of the highest interest. A communication received latter in the session, from Mr. R. Chalmers, on the Postpliocene of the same region, has further added to our knowledge of this interesting region, on the confines of New Brunswick and Quebec. In connection with more Western regions, Dr. Selwyn, of the Geological Survey, has presented a paper on discoveries of fossil plants in the Lignite tertiary of Roches Percées, in the Western Territories. Another interesting geological subject was that of the structure of the Peace River District, as explained by Dr. G. M. Dawson,

and more especially the recognition in that region of the Cretaceous series represented farther south, holding not only valuable beds of coal, but also fossil plants, seeming to connect some of the distinct floras recognised by American palæontologists to the southward. Having referred to the papers of Dr. Osler on Fresh Water Polyzoa, Mr. Donald on Baking Powders and Dr. Edwards on the qualities of certain Well-water, he said that much interest had been added to the meetings by the specimens submitted by their zealous curator, Mr. Muir, to whom they were also indebted for an illustration of a new illumating lens for the microscope, which he himself had invented. A Committee had been working throughout the Session in arranging for the visit of the American Association for the Advancement of Science in 1882, and it was hoped that their efforts would be successful in bringing about a scientific meeting even more successful than that of 1857.

In the absence of Mr. Whiteaves, who has removed to Ottawa, Mr. G. L. Marler read the following

REPORT OF THE CHAIRMAN OF COUNCIL.

Your Council has to regret the loss; since last annual meeting, of several of your most active members by the removal to Ottawa of the Geological Survey. Your Society has, by such removal, been deprived of a number of very active members, and your Council takes this opportunity of tendering to these gentlemen its sincere thanks for the valuable services they have rendered the Society, and hopes that although removed from this city they will not cease to interest themselves in the Society's proceedings, but will continue their connection with it as corresponding members. To attain this end your Council recommends that these gentlemen be regularly elected corresponding members.

During the Session now about to close your museum has received large additions both by purchase and donation. The specimens in the museum have been cleaned and remounted. This has added very materially to their appearance and value. Improvements have also been made in the building, and though much has been done, much yet remains to be done to carry out the proposed alterations and to make the building and its contents more worthy the objects for which they exist.

The land adjoining the building on the north side having passed out of the hands of the Royal Institution, and building thereon having been commenced, certain necessary expenses will in consequence fall on your Society. Arrangements have been made between your Society and the proprietor of the land adjoining your building to the north, to cede to him the few inches of land lying between your property and his, and for the sale of that portion of the north wall which he intends using and the land on which it rests. This will oblige your Society to alter the slope of the roof, to close three of the windows and to make other alterations; this arrangement has been made under your resolution approved of by your Council.

The usual free course of Somerville lectures was duly given to the number of six. Your Council recommends that the thanks of your Society be tendered and conveyed to the gentlemen who so kindly and ably gave their valuable time and labour in the preparation and delivery of these lectures, which, as proved by the large attendance, were well received and much appreciated. The lectures were as follows:

1881.

Feby. 3rd. On Mind in Nature. By Principal Dawson.

Feby. 10th. On Magnetism and Electricity as aids to Intelligence. By Dr. Barnes, Point St. Charles.

Feby. 24th. On Sugar and its Varieties. By Dr. J. Baker Edwards.

March 3rd. On the Brain as a thinking organ. By Dr. Osler.

March 10th. On Tobacco and its effects on the Brain, the Nervous System and organs of Vision. By Dr. Buller.

March 13th. On the Whence and Whither of a Sunbeam. By H. Sugden Evans, Esq., F.C.S.

Your Council thinks that the change of Janitor has been beneficial to your Society, and hopes that it may not be long before your resources will enable your Society to employ permanently a regular Taxidermist. This is now almost a necessity as the Museum must henceforth attract more attention from the public

owing to removal to Ottawa of the Geological Survey. Your Council has also to report that the annual field-day took place as usual, Lachute being the place selected for exploration; the day was everything that could be desired, and the Council would not only recommend that these field-days be kept up but would suggest that several be held through the summer.

As Treasurer of the Society, Mr. Marler presented the subjoined

TREASURER'S REPORT.

Your Treasurer has much pleasure in reporting that notwithstanding the large amount expended in improving the Museum and adding to it a large number of valuable and rare specimens, your Society has been able to reduce the mortgage on the property by paying a sum of $250, leaving only a balance of $250 to be paid, and there yet appears to your credit a balance of $74. Like every other institution your Society is feeling the influence of the good times upon which our country is now entering. This is seen from the fact that members who were in arrears with their membership fees are now making payment of the same. Your Treasurer hopes therefore to be able to show at an early date the mortgage on the building paid off and a considerable balance on hand.

G. L. MARLER in account with THE NATURAL HISTORY SOCIETY OF MONTREAL, from May 19th, 1880, to May 18th, 1881.

Dr.		*Cr.*	
1880. May 18.		1881.	
To balance on hand	$268.61	By Printing and Advertising	$135.12
		" Additions and repairs	270.00
1880–81.		" Petty repairs, furnishing, etc	43.96
To Government grant	700.00	" Salaries, gratuities and labour	457.00
" Donation from Mr. Hy. Joseph	10.90	" Gas and Water	147.25
" Rent of Rooms	510.50	" Editing *Naturalist*	50.00
Entrance Fees to Museum	75.80	" Excursion	30.00
Members' Fees	409.63	" Plumbing and Gasfitting	15.16
		" Hire of Piano, old account	10.00
		" Directory, John Lovell	2.50
		" Wood and Coal	129.82
		" Insurance	35.00
		" Repairs, (windows in upper part, &c.)	236.04
		" Interest on debt	30.00
		" Dawson Brothers' account	55.25
		" Hy. Joseph, Esq. on account of debt	252.95
		" Balance on hand	75.39
	$1975.44		$1975.44

Outstanding Debt on Mortgage, $250.00.

Examined and found correct, L. A. HUGUET LATOUR, *Auditor.*

G. L. MARLER
Treasurer.

Mr Muir then presented the

REPORT OF THE CABINET KEEPER AND OF THE LIBRARY COMMITTEE.

This report may be arranged under three divisions.

1.—Work on the Building.
2.—Work in the Museum.
3.—Report of Library Committee.

1st. Work on the Building.—On the left hand side of the entrance hall, a convenient store-room has been added, the ceiling of which gives a floor suitable for the accommodation of several specimens formerly in the Museum. The side entrance has been enclosed by a ceiling and partition, forming an inside porch, adding greatly to the comfort of the place in winter; and the head of the rear stairway leading up to the gallery has been floored over, increasing the accommodation offered by the gallery. Eleven windows have been put in on three sides of the gallery, giving increased cheerfulness and light; curtains have also been placed on the sky-lights. The large wall cases, twenty-seven in number, have been cleaned and painted, the shelves made narrower and better adapted to show the specimens thereon. The north and south sides of the gallery fronts have been raised, levelled and supported. The benches in the Lecture Hall have been repaired and strengthened by bolts.

2nd. Work in the Museum.—The whole of the birds, (1194 in all), the mammals, reptiles and fishes have been thoroughly dusted and cleaned; the birds have been re-mounted on handsome black walnut stands and painted blocks and the old soiled labels replaced by new ones; the fishes have been removed to the aquarium room, and the mammals re-arranged and put in the space thus left vacant. The whale, two of the alligators, and the large seal have been removed to the floor covering the store-room to the left of the main entrance hall, and the floor cases, formerly in the aquarium room, have been brought into the main room. Mr. John S. Brown having offered to stock and take charge of the aquaria for the Society, two aquaria loaned by Messrs. Wm. Muir and Jas. Ferrier, jr., together with those belonging to the Society, have been placed in position, and it is hoped that before the season is over a good representation in this department will be one of the attractions of the Museum. Mr.

Brown has also generously offered to pay the cost ($6) of tables upon which to place the aquaria.

The following is the list of birds found to be so much injured that they were destroyed:

Grass Finch *Poecetes gramineus.*
Purple Martin, *Progne purpurea.*
Red-shouldered Hawk, *Buteo lineatus.*
* Lesser Red Poll, *Ægiothus linaria.*
Common Crow, *Corvus Americanus.*
Yellow-throated Fly Catcher, *Vireo flavifrons.*
Cat Bird, *Galeoscoptes Carolinensis.*
Brown Thrush, *Harporhynchus rufus.*
Red-eyed Fly Catcher, *Vireo olivaceus.*
* Sparrow Hawk, *Tinnunculus sparverius.*
* Shore Lark, *Eremophila cornuta.*
Satin Grakle (female), *Kitta holosericea.*
Great Northern Shrike (old male), *Collyrio Borealis.*
" " " (female) " "
Dipyllodes magnifica. New Guinea. J. F. W.

* These three have been replaced—and it is to be hoped that if any of our members can aid us in replacing the others they will do so.

The following are the additions to the Museum since June, 1880:

DONATIONS WITH NAMES OF DONORS.

Apatite crystal, from Bob's Lake, Bedford, Ont. W. J. Morris, Esq.
Moss, coated with mineral matter, from Colorado. Dr. Kennedy.
Collection of English Plants. Col. G. E. Bulger, F.L.S., F.Z.S.
A fine *Limulus polyphemus.* Miss E. Mathewson.
Grey Squirrel, *Sciurus Carolinensis.* N. P. Leach, Esq.
Albino Robin, *Turdus migratorius.* "
Barred Owl, *Syrnium nebulosum.* J. A. Ogilvy, Esq.
" " " " Jno. Nichols, Esq.
Horned Grebe, *Podiceps cornutus.* "
Great Blue Heron, *Ardea herodias.* Geo. Edwards, Esq., Thurso.
Blue Jay (2), *Cyanura cristata.* G. L. Marler, Esq.
A Remora or Sucking Fish. Geo. F. Phelps, Esq.
A Bull-head Fish. "
Head of a male Salmon. Robt. J. Fowler, Esq.
A box made out of a plank from the Royal George, and a lock of Grace Darling's hair. Capt. Dutton, S. S. Sardinian.
Wild Goose (2), *Bernicla leucopareia.* G. L. Marler, Esq.
Brant Goose, *Bernicla Brenta.* "
American White-footed Goose, *Anser albatus.* "
Hare (mongrel). P. Keutzing.
Prairie Wolf. Chas. Selwyn, Esq.
44 Specimens of *Lepidoptera.* P. Keutzing.

PURCHASES.

BIRDS.

Belted Kingfisher, *Ceryle Alcyon.*
Coot, *Fulica Americana.*
Baltimore Oriole, *Icterus Baltimore.*
Sparrow Hawk, *Tinnunculus sparverius.*
Shore Lark, *Eremophila cornuta.*
Loggerhead Shrike (male and female) *Collyris Ludovicianus.*
Bonaparte Gull (Young), *Larus Bonapartii.*
Black-bellied Plover (2), *Squtarola helvetica.*
Loon, *Colymbus glacialis.*
Spruce Partridge, *Tetrao Canadensis..*
Hooded Merganser, *Lophodytes cucullatus.*
Goshawk, *Astur atricapillus.*
Goshawk (old) "
Horned Grebe, *Podiceps cornutus.*
Royal Tern, *Sterna Regia.*
Brewers Duck, *Anas Breweri.*
American Avoset, *Recurvirostra Americana.*
Great Marbled Godwit, *Scolopax fedoa.*
Red-necked Grebe (2), male and female, *Podiceps rubricollis.*
" " young, "
Ruddy Duck (2), male and female, *Fuligula rubida.*
Greater Blackhead Duck (2), male and female, *Fuligula marila.*
Snowy Owl (2), *Stryx Nyctea.*
Herring Gull, *Larus argentatus.*
Killdeer (young), *Ægialitis vociferus.*
Harris Woodpecker (2) male and female, *Picus Harrisi.* Vancouver's Island.
Yellow Rail, *Rallus noveboracensis*, Labrador.
Arctic Towhee (male), *Pipilo arctica.*
Fork-tailed Fly Catcher, *Muscicapa savanna.*
Horned Grebe (winter plumage), *Podiceps cornutus.*
Great Northern Diver, *Colymbus glacialis.*
Black-throated Diver, *Colymbus arcticus.*
Snow Bunting (2), *Plectrophanes nivalis.*
Black-throated Blue Warbler, *Dendroica Canadensis.*
" " Green " " *virens.*
Black and Yellow, " " *maculosa.*
Green Black Cap Fly Catcher (male, winter plumage), *Muscicapa pusilla.*
Mealy Red Poll (summer plumage) *Ægiothus exilipes.*
Little Minaret, *Pericocotus peregrinus.*
Wild Pigeon, *Ectopistes migratoria.*

MAMMALS.

Canadian Lynx, *Lynx Canadensis.* St. Jerome.
Racoon (old female), *Procyon Lotor.*
" (young), "
Mink, *Putorius vison.*
Weasel (2), *Putiorus vulgaris.*
Prairie Dog, *Spromophilus ludovicianus.*

Skins presented on a former occasion by the Smithsonian Institute and now mounted:

California Grey Squirrel, *Sciurus fossor.*
Thirteen Striped Squirrel (2), *Spermophilus tridecemlineatus.*
Mice (7)—various species.

Skins re-mounted:

Red-shafted Woodpeckers (2), *Picus querulus ?.*
Swift Parakeet, *Melopittacus undulatus.* Australia.
Hardwicke Shrike, *Collyrio.*
Yellow Bird (female), *Chrysomitris tristis.*

3rd. Report of Library Committee.—List of books, pamphlets and periodicals received into the library during the year ending May 1st, 1881:

American Journal of Science. Vol. 19, Nos. 110, 113; Vol. 20, Nos. 115, 116, 117, 118, 119, 122, 123.
Boston Society of Natural History. Vol. 20, Part 3.
American Philosophical Society. Vol. 18, No. 105.
Canadian Antiquarian and Numismatic Journal. Vol. 8, Nos. 3, 4; Vol. 9, No. 3.
Canada Medical and Surgical Journal, for the year.
Canadian Entomologist, "
Le Naturaliste Canadien, "
Statutes of Canada. Vols. 1 & 2. 1880.
Geological Record for 1877, by Wm. Whitaker. London, 1880.
United States Fish Commission Report; from Smithsonian Institute.
Scientific Proceedings of the Royal Dublin Society, from Nov. 1877 to July, 1880.
Scientific Transactions of the Royal Dublin Society, from Nov. 1877 to June, 1880.
Academy of Natural Sciences of Philadelphia. Parts 1st and 2d. Jany. 1880 to Sept. 1880.
Proceedings of the Rhode Island Historical Society, 1879–1880 and 1880–1881.
Transactions of the Connecticut Academy of Arts and Sciences. Vol. 1, Part 2, 1867 to 1871.
Annals of the Lyceum of Natural History. Vol. 11, No. 13.

Annals of New York Academy of Science, late Lyceum of Nat. His. Vol. 1, Nos. 11 to 13.

Contributions to Archæology of Missouri; from St. Louis Academy of Science. Part 1. Pottery. 1880.

Proceedings of the American Philosophical Society, 100th Anniversary, at Philadelphia. March, 1880.

Geological and Natural History Survey of Minnesota, 8th An. Report, 1879.

The American Antiquarian.

The American Naturalist. Vol. 14, Nos. 8 to 12; Vol. 15, Nos. 3 to 5.

Annals of the Museo Nacionalde. Mexico, 1880.

Journal of the Linnæan Society of London. Vol. 14, No. 80; Vol. 15, Nos. 81 to 83; Vol. 17, Nos. 103 to 107.

Proceedings of the Royal Society of London. Vol. 29, No. 197 to 205. June 1879 to June 1880.

Transactions of the Edinburgh Geological Society. Vol. 3, Part 2. 1879.

The Glasgow University Calendar, 1880–1881.

Science Gossip; for the year.

Quarterly Journal of Microscopical Science, for the year.

Journal of the Royal Microscopical Society, for the year.

Journal and Proceedings of the Royal Society of New South Wales. Vol. 12. 1878.

Transactions of the Philosophical Society of Adelaide, South Australia. Vol. 1, 1878; Vol. 2, 1879; Vol. 3, 1880.

Geological Survey of Canada. Report of Progress. 1878–1879.

Annual Report of the Entomological Society of Ontario for 1880.

Bulletin of the Essex Institute. Vol. 12, No. 769.

Ninth Annual Report of the Curators of the Wesleyan University, Middleton, Conn., U. S., 1880.

Nature. London. A Weekly Journal; for the year.

Archives Neerlandaises des Sciences Exactes et Naturelles—Societé Hollandaise des Sciences, Haarlem.

Archives Musée Teyler.

Nederlandsch Meteorologisch Iuarbackvoor, 1879.

Sitzungs–Beritche der Naturwissen schaftlichen Gesselschaft Isis in Dresden, 1879 and 1880.

Zeitschrift der Deutschen geologischen Gesellschaft—Berlin, 1879. 2 Vol. One No. April to June 1880.

Leopoldina. Dresden. Jany. 1878, Jany. 1879.

Nova Acta Academæ Cæseræ Leopoldina-Carolinæ, Germanical Naturæ curiosorum. Dresden and Halle, 1878.

Brachiopodes Etudes Locales. Extraits du Silurien du centre de la Bohemé. Vol. 5. Par Joachim Barrande. Paris.

Memoires de L'Academie des Sciences, Arts et Belle-Lettres des Dijon. 1878–1879.

Beritche uber die Verhandlungen der Koniglick sachsischen Gesselschaft der Wissenchaften Zur Liepzig. 1879.

Abhaudlungen der Mathematish-physischen classe der Kōnigl, clas 12, Nos. 2 to 4. Leipzig, 1879–1880. Also, No. 2, 1879.

Annals of the Museo Nacionalde. Mexico. Part 2. 1880.

Bulletin de la Societé Imperiale des Naturalistes de Moscow. Nos. 1, 2, 3, 4. 1879.

Acta Horti Petropolitani. Tomus VI, Fasciculu 2. St. Petersburg.

Bulletin et Memoires de Université Imperiale de Kazun (en Russe) 1879. No. 1 to 6.

Transactions of the Edinburgh Geological Society. Vol. 3, Part 3. 1880.

Proceedings and transactions of the Nova Scotian Institute of Natural Sciènce. Vol. 5, Part 2. 1879–1880.

Report of the Wisconsin Naturalist Society, German. 1880–1881.

Annual Report of the Department of Mines, New South Wales. 1880.

Do. do. do. for 1880. With maps.

Transactions of the American Philosophical Society. Vol. 15, New Series, Part 3.

Proceedings of the Royal Geographical Society. London. Vol. 3. No. 4.

In concluding my report allow me respectfully to suggest to the Council the following necessary and desirable repairs, improvements and additions in the Museum and building, besides those rendered necessary by the construction of the building on the northern side:

1st. The drains will require to be lowered, to enable them to drain the water from the under part of the furnaces.

2nd. In the heating department a new furnace or furnaces will be required (the old ones are worn out), which, in addition to the present heating arrangements, shall convey a shaft for hot air to the floor of the Museum.

3rd. The excessively crowded condition of the Hall on the occasions of the Somerville lectures revealed the necessity of providing for the more rapid influx of fresh air and egress of heated air. Increased accommodation can also be partially provided by arranging the folding doors on the north-east corner of the Hall so that they can be thrown open if desired.

4th. The addition to our stock of birds and mammals during the past year and the likelihood of equal addition during the coming year necessitates the acquirement of more wall cases in the Museum.

The Secretary then read the

REPORT OF EDITORS OF THE "CANADIAN NATURALIST."

The Editors of the "*Naturalist*" would report that this Journal has been issued as usual during the past year, four numbers having appeared since last annual meeting. They regret to state that but scanty material has during the past year been placed at their disposal by members of the Society. They would again urge upon members the necessity of doing all in their power to contribute and procure articles suitable for the Society's publication.

It was agreed on motion of Dr. DeSola that the reports now read be received and adopted and printed in the *Naturalist* and that a Membership Committee be appointed to enlarge the subscription roll and increase the interest in the Society.

Dr. A. R. C. Selwyn was proposed as an honorary life member; Dr. Ross was proposed as on ordinary member, and Dr. Robert Bell, Dr. G M. Dawson, Messrs. Foord, Ells, Richardson and Whiteaves, as corresponding members.

The election of officers was then proceeded with, resulting as follows:

President—Principal J. W. Dawson, LL.D., F.R.S.

Vice-Presidents—The Rev. Dr. DeSola, Mr. J. H. Joseph, Prof. P. J. Darey, Dr. T. Sterry Hunt, Major H. Latour, Dr. A. R. C. Selwyn, Dr. Hingston, Prof. B. J. Harrington and Mr. D. A. P. Watt.

Recording Secretary—Prof. F. W. Hicks, M.A.

Corresponding Secretary—Dr. J. Baker Edwards.

Treasurer—Mr. G. L. Marler.

Cabinet-Keeper and Librarian—Mr. Wm. Muir.

Council—Messrs. Thomas Craig, J. T. Donald, J. Bemrose, H. M. Sanborn, Dr. Osler, the Rev. Mr. Empson, M. H. Brisette, John S. Brown and S. Bagg.

Library Committee—Messrs W. Muir, J. Bemrose, J. S. Brown and J. T. Donald.

Editors of Canadian Naturalist—Professor B. J. Harrington and Mr. J. T. Donald.

Mr. Wm. Muir gave notice of motion to alter the by-law concerning annual membership fee.

The meeting then adjourned until June 16th.

The adjourned annual meeting was held on June 16th. Principal Dawson in the chair.

The minutes of the meeting of May 18th having been read and sustained, it was moved by Mr. J. H. Joseph, seconded by Prof. F. W. Hicks, and resolved : that in accordance with notice given at the meeting on the 18th ult., "the annual subscription to the Society be reduced to four dollars including the subscription to the *Naturalist* and to three dollars without the *Naturalist*.

The chairman of Council and the Recording Secretary were requested to issue a circular announcing the change in the subscription and urging members to endeavor to increase the membership list."

Messrs. Geo. Craig and P. Keutzing were proposed as ordinary members, after which the meeting adjourned.

Session 1881–82.

The first meeting of the Society, for this session, was held on the evening of November 7th—Principal Dawson occupied the chair. Minutes of last meeting being read and sustained, it was resolved, on motion of J. S. Brown, Esq., seconded by J. H. Joseph, Esq., "To sell to Mrs. F. W. Thomas the portion of the Society's lot intervening between its building and the line of Mrs. Thomas' property, to the depth of the buildings on Mrs. Thomas' lots, and the mitoyenneté of so much of the wall of the Society's building as is used by Mrs. Thomas. This, in consideration of Mrs. Thomas paying the Society one-half the value of the portion of the wall and of the ground on which it is erected—the valuation of the wall to be made by Mr. Hutchinson—and the ground to be valued at $1.20 per square foot, English; and in further consideration of the Society's being suffered to retain the use of such of the windows as now overlook Mrs. Thomas' land, so long as the Society's building is used for the present purposes of a Museum, curator's residence and Lecture Room. But should it be converted to private uses, the Society will be bound to close its openings [overlooking said Mrs. Thomas' land; the Society to bar their windows so that access to Mrs. Thomas' land may be prevented, and that the President and Treasurer be authorised to carry this resolution into effect, and to sign all necessary deeds, and to receive the price and grant discharge therefor."

It was also resolved, "That use of Lecture Room be granted free of expense, except for gas and heating, to the ladies of the Industrial Rooms, for holding a bazaar sometime in December, the details to be arranged by the Treasurer."

Messrs. G. W. Craig and P. Keutzing were elected members of the Society, and Mr. M. C. Baker was proposed for ordinary membership.

Major Latour proposed as honorary member His Excellency Dr. Renard, Conseiller d'état actuel de Moscou.

A collection of Resins, presented to the Museum by J. Lorne McDougall, Esq., was exhibited, and it was announced that Dr. Edwards and Mr. Donald would report on the same at a future meeting.

Dr. Dawson congratulated the Society on the result of the invitation to the American Association, and stated that in due time a meeting of influential citizens would be called to make suitable arrangements for entertaining the Association.

Dr. J. Baker Edwards presented a paper entitled "Resumé on Water analysis: new methods and recent results," which will be found in full at page 87.

Dr. W. Osler then read a series of "Microscopic Notes," which will be published in a future number.

The second meeting was held on Nov. 29th. The President occupied the chair.

The minutes of the previous meeting were read and approved.

Mr. Muir called the attention of members to several important additions recently made to the Library and to the Museum, the latter consisting of specimens purchased by the Society and mounted.

Mr. Muir then moved, seconded by the Rec. Secy., "That the President and Secretary be requested to draw up and forward, in the name of the Society, a resolution of condolence, expressing the sorrow of the members of the N. H. Society at the death of the late Lieut.-Col. Bulger, to whom the Society is very largely indebted for additions to the Museum."

Moved by Dr. Edwards, seconded by Prof. Darey, "That the use of the Museum and Library be permitted to the Auxiliary Association of Christ Church Cathedral, on the evening of Dec. 1st, on condition that they pay the expense of lighting, &c., as arranged by the Treasurer."

His Excellency Dr. Renard, Conseiller d'état actuel de Moscou, was elected an honorary member, and Malcolm C. Baker, Esq., Montreal, an ordinary member.

Dr. Edwards presented the report prepared by himself and Mr. Donald, on the Resins presented to the Museum by J. Lorne McDougall, Esq.

The collection consists of specimens of the following "gums": Zanzibar, Manilla, Kowrie, Damar, Benguela, Angola, Sierra Leone Copal, Asphaltum, Orange Shellac and Bleached Shellac. Dr. Edwards described the sources of these "gums," and Mr. Donald furnished information obtained from Messrs. McDougall, Logie & Co., concerning their uses and commercial values.

The Recording Secretary read the paper entitled "Notes on Fossils recently found near Campbellton, Baie de Chaleurs," forwarded by Mr. Whiteaves.

During the reading of the paper the subject was illustrated by means of diagrams and specimens from his own collection, by Principal Dawson, who at the conclusion described at length the geology of the locality in which the fossils had been found.

Presidents of the Natural Society of Montreal, 1827—1881.

1827–28.—Stephen Sewell.
1828–29.—Honorable Chief Justice Reid.
1829–30.—Honorable John Richardson, M.C.E.
1830–31.—Honorable Lewis Gugy.
1831-32.—Honorable Toussaint Pothier.
1832–33.— " " "
1833–34.—Revd. J. Bethune.
1834–35.—William Robertson, M.D.
1835–36.—Alexander Skakel, A.M,
1836–37.—Andrew F. Holmes, M.D.
1837–38.— " " "
1838–39.— " " "
1839–40.—
1840–41.—Andrew F. Holmes, M.D.
1841–42.—William Badgley.
1842–43.—John Brondgeest.
1843–44.— " "

1844–45.—M. McCulloch, M.D.
1845–46.—John Brondgeest.
1846–47.—J. Crawford, M.D.
1847–48.—A. H. David, M.D.
1848–49.—A. C. Sewell, M.D.
1849–50.—A. H. David, M.D.
1850–51.—John Ostell.
1851–52.— " "
1852–53.—A. Charles Sewell, M.D.
1853–54.—Major R. Lachlan.
1854–55.—Revd. W. T. Leach, D.C.L.
1855–56.—The R. R. the Lord Bishop of Montreal and Metropolitan.
1856–57.—Principal J. W. Dawson, F.G.S.
1857–58.— " " " "
1858–59.— " " " "
1859–60.—The Lord Bishop of Montreal (Fulford).
1860–61.— " " " "
1861–62.— " " " "
1862–63.— " " " "
1863–64.—Principal J. W. Dawson, LL,D., F.R.S.
1864–65.— " " " " "
1865–66 —Charles Smallwood, M.D., LL.D., D.C.L.
1866–67.—T. Sterry Hunt, LL.D., F.R.S.
1867–68.—Revd. Abraham De Sola, LL..D.
1868–69.—Principal J. W. Dawson, LL.D., F.R.S.
1869–70.—Sir William E. Logan, LL.D., F.R.S.
1870–71.—Principal J. W. Dawson, LL.D., F.R.S.
1871–72.— " " " " "
1872–73.—George Barnston.
1873–74.—Principal J. W. Dawson. LL.D., F.G.S.
1874–75.—A, R. C. Selwyn, F.R.S., F.G.S.
1875–76.— " " " "
1876–77.—Principal J. W. Dawson, LL.D., F.G.S.
1877–78.— " " " " "
1878–79.— " " " " "
1879–80.—A. R. C. Selwyn, F.R.S., F.G.S.
1880–81.—Principal J. W. Dawson, LL.D., F.G.S.

MISCELLANEOUS.

A Fossil Phyllopod Crustacean from the Quaternary Clays of Canada.—We have received through the kindness of Principal J. W. Dawson, LL.D., of Montreal, a valve in partial preservation of an Estheria quite unlike any existing American form. The following account of its discovery is from Principal Dawson :

" It was found at Green's Creek on the Ottawa river, in nodules in the Post-pliocene clay, holding skeletons of *Mallotus villosus* and other northern fishes, and shells of *Leda (Portlandia) arctica*, *Saxicava rugosa*, &c.; also leaves of Populus, Potamogeton, &c. The deposit is of the age of the Leda clay of the St. Lawrence (middle glacial) and belongs to a period of submergence when

in the bay or estuary then representing the Ottawa river, northern marine animals were imbedded in deposits into which was also washed the débris of neighboring land, and of fresh water streams. The climate at the time was colder than at present, and the area of land less, so that if this Estheria still lives, it is most likely to be found in the vicinity of the Arctic coast."

This Estheria is entirely unlike any northern American or European species, differing decidedly from *Estheria morsei* or *E. caldwelli* and *E. clarkii* It rather approaches *E. jonesii* from Cuba in the form of the shell and style of marking of the valves. It does not resemble closely any of the fossil forms figured in Jones' Monograph of fossil Estheriæ. The markings, however, present some resemblances to *E. middendorfii* Jones, but differ in the want of anastomosing cross wrinkles between the ridges.

One valve and portions of others were preserved; but none of them show the beaks (umbones), though the form of the remainder of the shell indicates that they were situated nearer the middle of the valve than usual, *i e.*, between the middle and the anterior third of the shell. The shell is deep, probably more so than in *E. jonesii*, though the valves have evidently been flattened and and somewhat distorted by pressure, but apparently the head-end was more truncated than in *E. jonesii*, as the edge of the shell and the parallel lines (or ridges) of growth along the head-end are below bent at right angles to the lower edge of the shell. The raised lines of growth are very numerous and near together; they are of nearly the same distance apart above near the beaks as on the lower edge. The very numerous lines of growth are thrown up into high sharp ridges, the edges of which are often rough, finely granulated, and often the valleys between are rugose on the surface. In one or two places a row of papillæ for the insertion of spinules may be seen where the shell has been well preserved, and between many of the lines of growth there are irregular superficial ridges. Length 10 mm.; depth 7.5 mm.

The valve is evidently that of an Estheria, much truncated anteriorly, and with the lines of growth much thicker, higher and closer together than in any North American species known to us, and may prove when better specimens are found, to be allied to the tertiary Siberian *E. middendorfii*.

The species is named in honor of the discoverer, J. W. Dawson, LL.D., who has so persistently and ably investigated the Leda clays of Canada. *A. S. Packard, jr.*—(*From the American Journal of Science.*)

GEOLOGICAL SOCIETY OF LONDON.

Extract from proceedings; Nov. 16, 1881.

UNIFICATION OF GEOLOGICAL NOMENCLATURE.

Prof. HUGHES said that he proposed to issue to the Committee of organization for Great Britain a full Report of the proceedings of the Bologna Congress; but in anticipation of that, he begged to offer to the Geological Society a brief statement of the results.

It would be within the recollection of the Fellows of the Society that, at the Geological Congress of Paris in 1878, two principal subjects were proposed for discussion at the Bologna Congress, and each was referred to an International Commission named by the Congress:—

1. The Unification of Geological Nomenclature.
2. Geological Cartography.

On the 2nd of April, 1880, the International Commission for the Unification of Geological Nomenclature was convened at Paris by the President of the Paris Congress and the President elect of the Bologna Congress, and the Commissioners present at that meeting, having regard to the impossibility of drawing up any thing like a complete report upon so vast a subject before the meeting of the Congress, and feeling that there would be much advantage gained by settling the meaning of the terms commonly used to designate the larger and smaller divisions of the materials which make up the crust of the earth, and the portions of time to which they are assigned, recommended that, first of all, these questions of a general character should be considered, such as the definition of epoch, period, formation, rock, &c., &c. A *résumé* of the reports of the different nationalities was drawn up by the General Secretary, M. Dewalque, and presented to the Congress, and the discussion was taken upon it. America and England were considered as one from the very first, a happy result of the friendly feeling that exists on all points between the two nations, and at Bologna cordially upheld by their distinguished guest of that evening Dr. Sterry Hunt.

The conclusions arrived at were briefly—that the term Group should be applied to the largest geological division of rocks, System to the next, Series to the third in order of magnitude, Stage to the fourth, and the French word Assise was placed in the fifth place, it being left to other nationalities to use whatever word in

their own tongue seemed most conveniently to represent this smallest defined term. The Time-words were, in descending order of magnitude—Era, Period, Epoch, Age—Era corresponding to Group, Period to System, Epoch to Series, Age to Stage. It was pointed out that the German and English use of the word *formation* for a set of deposits which it was desired to group together under one head, *e.g.* Carboniferous formation, could not be adopted by the French, with whom this word always had reference to the origin of the mass, and was considered an abbreviation of the *mode of formation*. This had been already fully recognized by the English Committee, in the minutes of one of the meetings of which the following resolution appears:—"The term Formation having been used by Continental geologists to denote the action by which a thing is formed, and its mode of formation, and its use in the sense accepted in England being given up in America, the Committee recommend that the term be employed as rarely as possible in the English sense, and that such words as group, rock, bed, &c., be substituted for it." It was pointed out by the German geologists that there were many nations who could not adopt "terrain," and therefore this word was also excluded from the more strictly defined terms. MM. Beyrich and Von Moeller explained that the word *series* could not be conveniently introduced into German or Russian, and it was therefore agreed that the words *section* and *Abtheilung* should be admitted as synonyms of *series*. It will be observed that there is a consistency in the group of words adopted in English, they are all what may be called synthetic; the analytic words such as division, subdivision, section, &c. remain undefined.

He regretted that they were not able to transpose the words Group and Series, as it certainly would be more convenient to to use *series* for the larger, and *group* for the smaller division; but it was not a matter of great importance.

In the course of the discussion, various speakers pointed out, by way of illustration, what they would include under these heads, and it was clear that there was very much to be done before any equivalent value could be attached to the subdivisions of different ages, or of the same general age, in widely separated areas.

The English Committee had commenced work upon this question, and he had laid before the Congress the Reports of the Sub-committees which had furnished him with the results of

their inquiries, as well as some special reports forwarded to him by individuals. The Congress did not, however, pass on to the discussion of these matters; but the manner in which the English Committee were organizing their work met with the approval of the Congress, and a vote was passed that the other countries should adopt a similar plan, and form sub-committees for the investigation of the several groups. He was further unofficially requested to get the reports printed as soon as possible, in order to facilitate discussion, and with a view to arriving at an understanding upon the simpler questions before the next meeting of the Congress. This was appointed to be held at Berlin in 1884. The following Congress will be held in England.

PRE-CAMBRIAN ROCKS.

Dr. T. Sterry Hunt gave some account of the pre-Cambrian or Eozoic rocks of Europe as compared with those of North America. He had on several occasions studied them, both on the continent and in the British Isles, especially with Dr. Hicks in Wales in 1878. In North America the recognised base is a highly granitoid gneiss, without observed limestones, which he has called the Ottawa gneiss, overlain, probably unconformably, by the Grenville series of Logan, consisting chiefly of granitoid gneisses, with crystalline limestones and quartzites. These two divisions make up the Laurentian of Canada, and correspond respectively to the Lewisian and the Dimetian of Hicks. Resting in discordance on the Laurentian, we find areas of the Norian or Labrador series (Upper Laurentian of Logan), chiefly made up of anortholite rooks, granitoid or gneissoid in texture, with some true gneisses. The Huronian is seen to rest unconformably on the Laurentian, fragments of which abound in the Huronian conglomerates. To the lower portion of the Huronian the speaker had formerly referred a great series of petrosilex or hälleflinta rocks, described as inchoate gneisses, passing into petrosilex-porphyries, occasionally interstratified with quartzites. This series, in many places wanting both in Europe and America, he is now satisfied forms an underlying unconformable group—the Arvonian of Hicks. Above the Huronian is the great Montalban series, consisting of grey tender gneisses and quartzose-schists, both abounding in muscovite, occasionally with hornblendic rocks. The Pebidian of Hicks includes both the Huronian and the Montalban, to which latter belong, according to the speaker, certain gneisses and mica-schists both in Scotland and in Ireland,

as he had many years since pointed out. In some parts of North America he found the Montalban resting unconformably on Laurentian. Above tho Montalban comes the Taconian (Lower Taconic of Emmons), a series of quartzites and soft micaceous schists, with dolomites and marbles. All these various series are older than the Lower Cambrian (Menevian) strata of North America; and it may be added that the Keweenian or great copper-bearing series of Lake Superior there occupies a position between the Montalban and the Cambrian.

In the Alps the speaker recognizes the Laurentian, Huronian and Montalban, all of which he has lately seen in the Biellese, at the foot of Mont Viso, in Piedmont. The Huronian is the great *pietre verdi* group of the Italians, and much of what has been called altered Trias in this region is, in his opinion, probably Taconian. The Montalban forms the southern slope of Mont St. Gothard, and is the muscovite gneiss and mica-schist of the Saxon Erzgebirge. Here Dr. Credner and his assistants of the Geological Survey have described abundant conglomerates holding pebbles of Laurentian rocks imbedded in the Upper or Montalban gneiss. The pre-Cambrian age of this has been shown by Credner, who has proved by careful survey that the so-called younger or Palæozoic gneisses of Naumann are really but a continuous part of the older series. Late surveys also show that the crystalline rocks of the Taunus are really Eozoic and not, as formerly maintained, Devonian in age.

The speaker insisted upon the fact that where newer strata are in unconformable contact with older ones, the effect of lateral movements of compression, involving the two series, is generally to cause the newer and more yielding strata to dip towards and even beneath the edges of the older rock, a result due to folds, often with inversion, sometimes passing into faults. This phenomenon throws much light on the supposed recency of many crystalline schists.

The following communications were read:—

1. "Additional Evidence on the Land Plants from the Pen y-glog Slate quarry, near Corwen." By Henry Hicks, Esq., M.D., F.G.S.

The author stated that since the date of his former paper (Quart. Journ. Geol. Soc., August, 1881) he had ascertained that plant-remains occurred in the slaty beds down to the base of the quarry, though much obscured by cleavage. The larger specimens are in the form of anthracite. Mr. Carruthers states that there is sufficient evidence to show that they are the remains

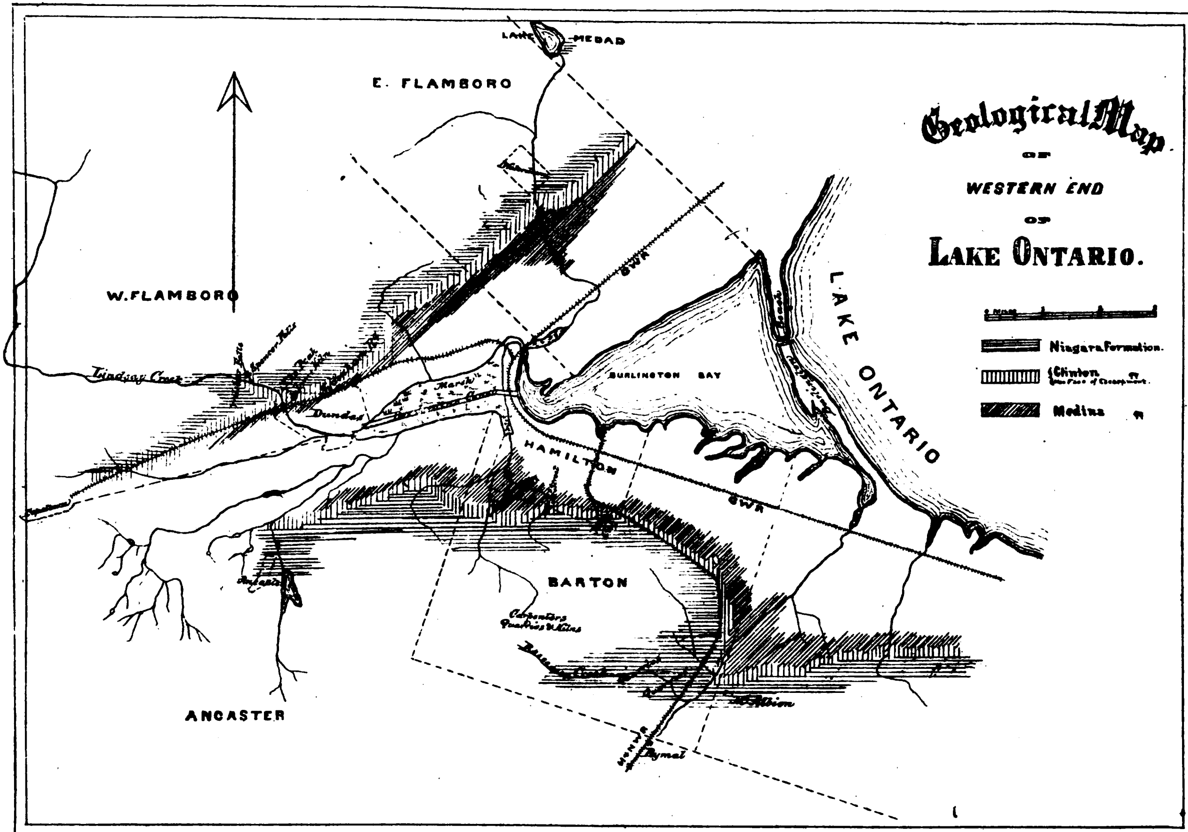
of vascular plants, with some resemblance to the Lycopodiaceæ. Some of the fragments are from 4 to 5 inches wide, and the author had traced trunks some feet in length. He thought they had drifted to the position where they were now found. Leaf-markings generally are not preserved; but from the wrinklings still remaining on some specimens, he thought it probable they had been covered with leaves spirally arranged. Some fragments show scars arranged irregularly on the surface; probably these are fragments of roots. The plant seems to some extent to combine the characters of *Stigmaria*, *Sigillaria*, and *Lepidodendron*. Further details of the appearance of the specimens were given. For one which appears to differ from all hitherto described he proposes the name of *Berwynia Carruthersii*.

2. "Notes on *Prototaxites* and *Pachytheca* from the Denbighshire Grits of Corwen, North Wales." By Principal Dawson, LL.D., F.R.S., F.G.S.

The author stated that he had obtained specimens of the Plant-remains from near Corwen, and that among them there were two kinds, one dark, the other light-coloured. In the former. the long cells and woody fibres are filled with rods of transparent siliceous matter, and the walls represented by a thick layer of carbon. The lighter kind consists of the siliceous rods alone, which are thus in the same state as the asbestos-like silicified Coniferous wood of the Californian gold-gravels. In both the siliceous rods show traces of the irregularly spiral ligneous lining of the cell-walls. From these and other characters the author refers the specimens to his genus *Prototaxites*, which, he says, is not an Alga, but a woody terrestrial plant. The author did not state that *Prototaxites* actually belonged to the Taxineæ, but that its fossilized wood showed a resemblance to that of some fossil Taxineæ. The remains discovered by Dr. Hicks differ, as already recognized by Mr. Etheridge, from *Prototaxites Logani*, Daws.; and the species may be named *P. Hicksii*.

Of *pachytheca* the author stated that he had specimens from the Upper Silurian of New Brunswick, and these and the Welsh specimens seem to belong to the genus *Ætheotesta*, Brongn., and to be nearly allied to *Æ. devonica*, Daws., from the Devonian of Scotland. These fossils occur associated with *Prototaxites*, not only at Corwen, but in the Upper Ludlow of England, in the Upper Silurian of Cape Bon Ami, and in the Lower Devonian of Bordeaux quarry opposite Campbellton in New Brunswick, and as the author maintains *Ætheotesta* to be a seed, and Brongniart compared it with the seeds of the Taxineæ, this may be taken as additional evidence in favour of the Taxine or, at any rate, Gymnospermatous nature of *Prototaxites*.

Published Dec. 30, 1881.


Geological Map
of
WESTERN END
of
LAKE ONTARIO.
Niagara Formation.
Clinton
Medina
LAKE ONTARIO
BURLINGTON BAY
HAMILTON
BARTON
E. FLAMBORO
W. FLAMBORO
ANCASTER
LAKE MEDAD
Dundas
Lindsay Creek
Albion
Rymal
G.W.R.
Carpenters Quarries & Kilns

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

PALÆOZOIC GEOLOGY OF THE REGION ABOUT THE WESTERN END OF LAKE ONTARIO.

By Prof. J. W. Spencer, B.A.Sc., Ph.D., F.G.S.,

Vice-President of King's College, Windsor, Nova Scotia.

Preface.—In 1874, I published, in this Journal, a short paper on the "Geology of the Neighbourhood of Hamilton." Subsequently (1877-80), I made an additional study of the region, and found an immense amount of geological information obtainable. This paper on the Palæozoic Geology was ready for print in the autumn of 1879, but its publication was delayed in order to complete the work; but as the completion seems some distance off, I present this paper on the first portion of the subject of the Geology about the Region of the Western End of Lake Ontario. A very large amount of new material in Palæontology has been collected and is now ready for press.

Although the principal facts of the Surface Geology have been collected, yet the study is not yet completed, it being very large, as more than local phenomena are involved.

I.—Introduction.

Skirting the Western End of Lake Ontario, in our Canadian Province of the same name, there are excellent exposures of the various portions of the Silurian formations (or Upper Silurian of the New York Geologists) overlying, to a depth of several hundred feet, the upper members of the Cambro-Silurian Age (of the Hudson River epoch) about the city of Hamilton,

whilst between Oakville and Toronto, the rocks of the latter age appear at the surface of the country.

Those members of the Silurian formation which are exposed in the region under consideration belong to the Medina, Clinton, and Niagara epochs. The best localities for making geological examinations are at Thorold, Grimsby, Hamilton, Dundas, Limehouse Station (G.T.R.) and Rockwood. Nowhere in Eastern America are there better exposures of the various rocks of this age, though in some localities, especially in the Western States, the fossils are in a better state of preservation. However, in the above localities there is a very great difference in the preservation of the fossils found, and nearly 200 species of organisms can be procured from a limited number of localities. A considerable variation of texture is observed in the rocks in the different places, and although the number of species of animal remains is considerable, yet owing to the crystalline texture of the limestones, one is rewarded with meagre returns for his day's labor.

As we will see further on, the rocks under consideration are intermediate in character between those of the State of New York to the eastward, and those of Ohio to the westward, being more calcareous than their equivalents in the former State, and more argillaceous than those in the latter.

In the study of the various rocks of the Niagara group, I have examined the microscopical structure, and have made a number of chemical analyses. At the end of the present paper there will be found a catalogue of all the species of fossils in my own collection, with some few that have been obtained by others, but of which I have not been fortunate enough to obtain specimens. This will be found to be the fullest catalogue of Canadian fossils from the Niagara group yet published.

Again, a few minerals are procurable at various localities from cavities in the Niagara limestones, as well as mineral waters from several natural springs and artificial openings, all of which will be noticed in their proper places.

As no part of the Province affords a greater variety of interest to the student of geology than the region about the western end of Lake Ontario, I will endeavour to give a full but concise account of those features and objects of attraction that will assist the geological observer and student in the pursuit of this most attractive and useful study of Nature.

II.—TOPOGRAPHY AND DISTRIBUTION.

Extending along the southern shores of Lake Ontario, at distances varying from one to a few miles from its waters, there is a ridge of hills, or more properly an escarpment, known to geologists as the "Niagara Escarpment," extending from the State of New York into Canada, and entering our country near Queenston, whence the *cañon* of the Niagara Falls has worked backward for several miles. From the Niagara River this ridge extends westward to the town of Dundas, and thence the trend is a little west of north to Lake Huron and Manitoulin Islands.

This range everywhere forms a bold feature. Along the southern shore of Lake Ontario, the brow is 400 feet above the lake, while near the "Peak," north of Dundas, the height is 520 feet, from which place the ascent is gradual as it extends northward, until just west of Limehouse, the cliffs have a height of 847 feet, whence the plateau gradually rises to 936 feet at Rockwood (on the G. T. Railway), and northward, in Amaranth township, it has an elevation of 1400 feet above Lake Ontario. In its course, south of Lake Ontario, the slope is generally more abrupt than after the range assumes a northerly trend,—the upper portion often forming almost perpendicular cliffs from 100 to 250 feet above the rising slope at its base. The brow where the H. & N. W. Railway ascends the mountain (four miles east of Hamilton) is 395 feet, and at the head of James street, Hamilton, it is 388 feet above the lake, while the plateau above gradually rises to 493 feet, five and a half miles south of the former place, and to 485 feet, two miles south of the latter. This height of land forms the watershed between Lakes Ontario and Erie, and from it the country gradually slopes to the latter lake.

The rocks of this range belong to the various subdivisions of the Niagara Group of the Silurian Age. The Canadian Geological Survey, many years ago, separated the Niagara and Guelph groups from the overlying Lower Helderberg group, and called these Middle Silurian, whilst the New York geologists placed them all together, and called them Upper Silurian. We will adopt that nomenclature which recognises the rocks of the various groups from the Niagara to the Lower Helderberg (inclusive), as being members, not of the middle or upper, but of the one great Silurian Age, and consider the Lower Silurian formations (Tren-

ton and Hudson River groups of America) of the New York Geological Survey, under the name Cambro-Silurian—a name given by one of the fathers of English Geology (Professor Sedgwick) before Sir R. Murchison included their Welsh equivalents as the lower portion of his "Silurian System," as the character of the organic remains is intermediate between *Sedgwick's Cambrian* and *Murchison's Original Silurian Systems.*

In the State of New York the Niagara group is divided in ascending order into the ONEIDA, MEDINA, CLINTON and NIAGARA EPOCHS, and overlies the Hudson River formation.

The Oneida of New York consists of a conglomerate, and is wanting in Canada, but all the other members of the series are present in the Province. At the head of Lake Ontario, the Medina is underlaid by the rocks of the Hudson River epoch; and the rocks of the Niagara period form the surface deposits adjacent to the lake region, while twenty miles to the westward, they are overlaid in the neighbourhood of the towns of Galt and Guelph by the deposits of the Guelph formation.

In the Niagara Peninsula, south of Hamilton, the Niagara formation is succeeded by some of the members of the Helderberg group, unless there be some thin concealed deposits of the Guelph group not exposed.

The general dip of the whole series is 25.5 feet in the mile in a direction of about twenty degrees west of south.

III.—GEOLOGICAL SECTIONS.

During the summer of 1879, the writer, with the assistance of the late George Beasley, Esq., C. E., made instrumental measurements of four Geological Sections—the most complete that could be obtained. Two of these sections were at Dundas, one at Hamilton, and one south-east of the city, from the water-shed between Lake Ontario and Lake Erie, along the exposures of the Niagara Limestones in the bed of the Rosseaux Creek, to its falls at Mount Albion. These measurements required several days' levelling over many miles of ground. In addition to the principal sections, several smaller exposures were measured in order to compare the continuity of various strata.

The thickness and character of the lowest portions of the Medina formation were ascertained from the log of an Artesian well, sunk to a depth of 1600 feet, in the western part of Dundas.

Mr. Beasley and myself connected the thickness between the adjacent summit of the Medina group, which is 264 feet above the lake, by levelling (and allowing for dip) with the mouth of the well of which we had the record, and were thus enabled to calculate accurately the thickness of the formation.

Before advancing further we will give a tabular view of the four sections measured.

The first section is at the western end of Dundas, (near the place where the Artesian well was sunk.) The height of the mouth of the well was found to be 139 feet above Desjardin's Canal. Afterwards we levelled to the summit of the cliffs along the south-western side of the ravine, which is formed by the union of the two streams from Spencer's and Webster's Falls—the highest point of the exposed rocks being at the junction of the two glens, where the top beds are composed of the cherty bands of the same horizon as those which form the capping strata south of Hamilton. By means of this section and the Artesian well, we were able to ascertain the whole thickness of the Medina formation, the whole thickness of the Clinton formation, and the lower portion of the Niagara proper.

But the western side of the ravine is more than one hundred feet lower than the eastern side, although the rocks are nearly horizontal. This has been owing to the local denudation in the spur of rocks between two great valleys, which will be noticed in a future paper on the surface geology.

The ravine or *cañon* just referred to is more than 300 feet deep, if we calculate from its eastern (or rather north-eastern) side. Owing to the absence of the higher beds of the series, we levelled up the escarpment on the opposite side of the great glen, at the Limekilns, just east of the " Peak," where the highest rocks are 516 feet above the lake, although the soil rises a few feet higher a short distance to the northward.

By these measurements, and the necessary calculations in correlating the adjacent measurements, it was found that the whole thickness of the Niagara group is 800 feet at Dundas, of which the lowest 545 feet belong to the Medina series.

The second section is along the Sydenham road at Dundas. The third section is at Hamilton, between the head of James street and the Jolly Cut road. The fourth section, as we have seen, was taken along the Rosseaux Creek to Albion Falls.

SECTION I. (at Dundas).

In descending order: Beds 20-14 were measured above Limekiln. Beds 13-2, measured at the south-western side of Glen Spencer, are correlated with those above. Series of beds numbered 1 is at Artesian Well.

Beds. No.	NIAGARA FORMATION.	Thickness. Feet.	
20	Fine grained gray arenaceous dolomite. Top bed glaciated. (Height above Lake Ontario 517 ft.) ..	10.6	
19	Dark dolomites (somewhat bituminous) containing concretionary masses of a brecciated appearance..	9.7	
18	Measures concealed..........................	10.2	
17	Gray and drab dolomites in thin beds—the upper portion forming brow of escarpment just east of "Peak."........................	28.3	
16	Earthy dolomites with conchoidal fracture.........	3.2	
15	Dolomitic shales covered with incrustations of epsomite....................................	3.5	
14	Gray and variegated dolomites in thin beds with earthy partings..............................	38.4	
		——	103.9
13	Cherty dolomites (?) concealed, by measurement 3.1 feet, but allowing for dip, 3.0 feet must be added, and this connects the section at the Limekiln with that measured at western side of Ravine from Webster's to Spencer's Falls....................	6.1	
12	Gray dolomites with numerous cherty nodules, this forms the brow of cliff at junction of Ravines from Spencer's and Webster's Falls..................	12.0	
11	Shaly dolomites, with shaly partings..............	2.0	
10	Compact dark gray dolomites, more or less argillo-arenaceous, in beds from two to two and a half feet thick....................................	16.9	
9	Dolomitic blue shales, with shaly dolomites........	13.1	
8	Compact light gray dolomite in one bed. This bed is constant for many miles, and it was from this that the dip was calculated, and checked in by other beds..................................	5.3	
7	Niagara dolomites, covered here, but exposed elsewhere....................................	10.0	
		——	65.4

	CLINTON FORMATION.		
6	Clinton bluish shales, with numerous thin beds of argillaceous dolomites, some of which are also very ferruginous, others are more arenaceous. Many contain fossils. Portions of the series are covered, but, being exposed in numerous places, show the character of the whole formation just described...	77.5	
5	Argillo-arenaceous dolomites, which may be considered as beds of passage to the Medina beneath.	8.2	
		——	85.7

Beds. No.	MEDINA FORMATION.	Thickness. Feet.	
4	Bluish sandstones in two beds, splitting in slabs....	2.7	
3	Coarse sandstone—the GRAY BAND—varying much in thickness. This is separated from the beds above by shaly parting..........................	7.3	
2	Medina shales — green, red, or variegated — partly covered here, but various portions exposed in many places..	141.0	
1	Red, green, and variegated shales (measured in Artesian Well)..	394.0	
		——	545.0
	Total thickness................		800.0

SECTION II. (at Dundas).

This section was measured partly along the Sydenham road, and partly in the glen just west of it. The measurements are in descending order, and the numbers of the beds refer to the equivalent beds in Section I.

	NIAGARA FORMATION.		
13 & 12	Cherty dolomites, forming brow of escarpment along Sydenham road. The upper portion in the section represented at the "Peak," by more than 100 feet, being removed by denudation for some distance back of the brow....................................	19.0	
11	Dolomitic shales.....................................	0.8	
10	Compact gray dolomite, more or less argillo-arenaceous, in beds from 2 to 2.5 feet thick.............	14.0	
9 b	Shaly dolomites....................................	4.5	
9 a	Dolomitic shales....................................	6.0	
8	Compact gray dolomite in one bed, highly crystalline, with cavities filled with minerals...........	5.5	
7	Gray dolomite, more or less argillaceous...........	10.0	
		——	59.8
	CLINTON FORMATION.		
6 & 5	Clinton shales, with thin beds of areno-argillaceous dolomites, sometimes ferruginous, some of the beds are fossiliferous. About 20 feet from the top there is a bed of red ferruginous, calcareo-arenaceous sandstone, rich in casts of fossils.................	85.7	
		——	85.7
	MEDINA FORMATION.		
4	Bluish sandstone splitting into thin slabs..........	2.1	
	Shaly parting.......................................	0.8	
3	Coarse gray sandstone—the "Gray Band"—varying in thickness from 6.7 to 9 feet..................	8.1	
	See below,		
2&1	Medina variegated shales (as calculated)..........	535.0	
		——	546.0
	Total thickness................		691.5

Section III. (at Hamilton).

This section was measured along the brow of the escarpment at the city of Hamilton, between the ravine at the head of James street and the "Jolly Cut" road, about half a mile to the eastward. The section is in descending order. The numbering of the beds connects the section with the corresponding beds at Dundas. (See note in Appendix.)

Beds. No.	Niagara Formation.	*Thickness. Feet.*	
12	Thin gray dolomites, with an abundance of cherty nodules. This bed is known as the "Chert Bed," and forms the brow of the escarpment at Hamilton and eastward, being 388 feet above lake at head of James street. At head of Queen street this series is 19 feet thick	12.0	
11 & 10	Argillaceous dolomites, with shaly partings—upper portion known as the "Blue Building Beds." Beds 0.5–1 foot thick. (See analysis and fossils.)	15.5	
9	Dark hard dolomitic shales and dolomites weathering to gray—and lower beds most shaly. (See analysis.)	10.5	
8	Thick bed gray crystalline dolomite (nearly pure)	4.5	
7	Argillo-arenaceous dolomite in beds from 1–1.5 feet thick. (See analysis)	8.8	
		——	51.3

	Clinton Formation.		
6*b*	Earthy dolomite, with shaly partings	8.0	
6*a*	Chinton shales, all dolomitic, with thin beds of harder rock, some of which are arenaceous, and others to a thickness of about 7 feet, are areno-ferruginous. The upper 9 feet may be considered as passage beds	76.9	
5	Passage beds of argillaceous dolomites. (Top projecting portion is glaciated, and is 254 feet above lake)	8.8	
		——	93.7

	Medina Formation.		
4 & 3	Coarse gray sandstone—"Gray Band." This bed varies in thickness	6.5	
2 & 1	Medina variegated red and green shales. Thickness from calculation of Dundas Artesian Well	538.5	
		——	545.0
	Total thickness		690.0

SECTION IV. (along Rosseaux Creek).

This section along Rosseaux Creek, extends from Albion Falls (in Barton Township) to Carpenter's Limekilns, on the Hamilton and Caledonia road. This line follows nearly the strike of the formation. The section is in descending order. The numbering of the beds refers to the corresponding strata at Hamilton and Dundas.

Only the Niagara Formation is represented.

Beds. No.		*Thickness. Feet.*	
	Dark gray bituminous dolomites at Carpenter's Limekiln, R. VI, lot 15, Barton. The top bed is two feet thick, with glaciated surface. This bed contains abundance of Stromatopora	11.5	
	Beds concealed	42.7	
	Grey bituminous dolomites (Range VII, lot 7, Barton) beds 0.25–1.0 foot thick, containing cavities filled with barite, calcite, selenite, fluorite, galenite, sphalerite, and other minerals in beautiful crystals, besides bituminuous matter	15.1	
	Covered beds	5.7	
	Earthy compact dolomite (Range VII, lot 5)	6.2	
	(The following is down the creek, R. VII, lots 4–1.)		
	Fine grained dark dolomite, in one bed, with glaciated surface	2.2	
	Areno-argillaceous dolomites, in thin beds with shaly partings, 0.2–0.4 foot thick	12.3	
	Dark brown flags, areno-argillaceous, with films of dolomite	1.3	
	Shaly dolomite (with abundance of *Streptelasma*)	2.5	
	Blue arenaceous shales, hardened with crystalline particles of dolomite	2.9	
	Argillaceous dolomites	3.2	
	Blue and red shaly rock	3.0	
	Dolomitic flags (Avicula bed), dark brown arenaceous	5.4	
	Covered beds	3.0	
	Earthy dolomites, forming bed of creek	7.5	
	Covered beds	3.7	
	Thin gray dolomites (areno-argillaceous), forming brow of escarpment, just west of Falls	4.0	
			132.2
11,12 & 13	Cherty dolomites, at Albion Falls	18.4	
10	Argillaceous dolomites, in thin beds, with shaly partings	22.6	
9	Blue hard dolomitic shales, with beds of shaly dolomites	12.0	
8	Gray crystalline dolomite, in one bed	4.9	
7	Argillo-arenaceous dolomites, in thin beds	7.7	
			65.6
	Total thickness of Niagara beds		197.8

IV.—THE MEDINA FORMATION.

In referring to the Geological Reports of the State of New York, we learn that the Medina formation rests on what is known as "Oneida Conglomerate," which in Oneida County has only a thickness of 25 feet, though elsewhere it is as much as 100 feet thick, while in the State of Pennsylvania it is developed to the extent of 700 feet. There appears to have been a gradual passage from the band of gray sandstone, terminating the Hudson River formation in Oneida and Oswego counties, to the overlying conglomerate, both of which deposits, however, are wanting in the western part of the State, and are entirely absent from the series in Canada, as indicated at a short distance east of Oakville, on the north-western side of Lake Ontario, where the upper beds belonging to the close of the Cambro-Silurian Age are seen to rest beneath those at the commencement of Medina epoch.

In tracing the Medina formation from Oswego County, N.Y., it is found to increase in thickness until it attains a development of several hundred feet in the western part of the State, and at Dundas, at the head of Lake Ontario, it is 545 feet thick. Again the group gradually dies out to the westward, and is only represented in the State of Ohio by ten or twenty feet of red and blue mottled shales.

Almost the whole series is made up of more or less calcareous shales, some of which are also arenaceous (and almost resemble thin flags of unpure sandstone). In color the shales are red, green, or variegated. The series is capped by a coarse sandstone, which is irregularly deposited and has a thickness in the region of Dundas and Hamilton, varying from seven to ten feet. It is known by the name of the "Gray Band," and is a characteristic stratum from the Niagara River to the Georgian Bay. Sometimes, however, it thins out to mere wedges, bnt the hollows occasioned by the sudden thinning process is filled up with earthy calcareous sandstones. This structure is well illustrated by a section in the glen just west of the Sydenham road, Dundas—the following section would not be represented longitudinally by more than thirty feet:

2.1 feet	Bluish sandstone	2.1 feet.
0.8 "	Shaly partings	0.8 "
3.7 "	Thin shaly sandstones	6.7 "
4.0 "	Sandstone: The "Gray Band."	
1.3 "	Sandstone	0.9 "

By this means it will be seen that the whole series does not materially alter in thickness, but that the undulations of the surface of the "Gray Band" resulted from unequal deposits of sand along the sea-margins, and afterwards the inequalities were filled up by sediments of slightly different character. Sometimss the "Gray Band" shows ripple marks on its upper surface, while the more shaly partings have their surface characterised by wave action.

At Grimbsy, the lower portion of this band is of the usual gray color, but it passes into bright red sandstones irregularly deposited, and conspicuously mottled by large spots of a gray tint. At this locality the *Arthrophycus harlani* is very abundant, and though found in both the gray and red sandstones, it is more common in the former.

At Dundas the capping portion of the "Gray Band" consists of a bluish sandstone resembling quartzite, though this subdivision in the character of the beds is not noticeable at Hamilton.

All the thicker beds of Medina sandstone form excellent building material, though difficult to work on account of its compactness and toughness.

Along the *cañon* of the Niagara River more than 200 feet of the shales are exposed. So, also, there are excellent exposures in many of the gorges about the head of Lake Ontario. Perhaps the best section of the shales is to be obtained by following up the stream which flows into Burlington Bay after passing by the village of Waterdown. In the deep gorge of this stream the upper 250 feet of Medina shale is more or less exposed, though in some places covered by land-slides. The base of the Medina is exposed at a short distance east of Oakville.

At Dundas, an Artesian well was sunk a few years ago, and the following is the log of the boring, as published in the *Dundas Banner*:

Boulder Till	26	feet.
Blue Clay	48	"
Clay and Black Sand	5	"
Red Shales	341	"
Limestone and Grits	550	"
Total Depth	1600	"

The record of the character of the lower portions of the boring was not given. The "limestone and grits" represent rocks of the Hudson River formation. The record also stated that at 290 feet from the surface there was a thin bed of sandstone with a flow of gas and water; at 300 feet there was a flow of water rising eight feet above the surface; at 970 feet there was a heavy flow of gas. This imperfect record is unfortunately all that remains of much money that was expended in seeking for a supply of water for the town. The secretary of the Well Company has since died, and the complete record is lost. However, it serves a purpose, and by connecting the levels of the mouth of the well (which is 139 feet above Lake Ontario) with the adjacent Medina beds, we are enabled to calculate the thickness of the whole formation.

Other wells have been sunk to a considerable depth, years ago, but unfortunately their logs are not in existence. One, at an oil refinery, east of Hamilton, was sunk into the Medina shales, or perhaps just through them, when a sufficient supply of water was obtained, but which was strongly alkaline (see analysis below). At 40 feet from the surface (about 275 from top of the Medina series) a thin bed of sandstone was found. Another thin bed of sandstone comes to an out-crop at Burlington, on the northern side of the bay of the same name. The beds found at these two places are probably of the same horizon although their continuity is broken by the cause which originated Burlington Bay.

There was another important well sunk to a depth of 1009 feet, at the Royal Hotel, Hamilton, but though some water was procured by me and then analysed, the record of the boring was lost in a burning building. The eastern part of Hamilton is situated almost directly on Medina clays; but the surface of these is covered to a considerable thickness in the western part of the city by drift, which partly fills a Pliocene valley. (See a future paper on Surface Geology.)

The character of the Medina shales is shown by the following chemical analysis. The specimen chosen was typical of the

green indurated shales which on weathering become red. It was obtaiued from a freshly broken surface at an artifical ditch in Ainsley's Hollow, west of Hamilton.

Silica	50·2
Alumina	12·0
Iron Protoxide	1·5
Lime	17·7
Magnesia	5·8
Carbon Dioxide	11·6
	98·8

A portion of the lime and magnesia was present as silicates, some of which was decomposed by acids. In various analysis of the Medina shale, made by Dr. Sterry Hunt, less than one per cent. of fixed alkalis was found to be present. Under the microscope, these rocks exhibit small crystalline dolomitic particles scattered through the mass, sometimes uniformly, and sometimes in thin layers.

From the geological evidence adduced by the Ohio Geological Survey (as will be noticed under the Clinton formation), the Hudson River formation was raised up into a shore line before the deposition of the members of the Niagara group. In the State of New York the Medina seas laved the shores of the Shawangunk Mountains, whence the pebbles for the conglomerate of the lower portion of the series were derived. The western margin of the sea was bounded by the "Cincinnati Arch," which has been an upland since the close of the Cambro-Silurian Age. The arenaceous material of the Medina series was obtained largely from the adjacent highlands to the eastward, although a portion of the sediments that form the "Gray band" was probably derived from the denudation of the more siliceous portions of the Hudson River formation of the Canadian shores.

The shaly beds of the Hudson River series, and particularly those of the Utica formation of the Canadian highlands, formed an abundant source whence denudations could derive an ample supply of clay to produce the wide-spread off-shore deposit of Medina shales in the northern portion of the sea. The period was generally one of subsidence until its close, when the "Gray band" was deposited, to be followed by the Clinton shallow seas, which were to be filled up with impure limestones, alternating with muddy sediments brought down from the adjacent shores.

Organic Remains.—One or two fragments of obscure sea-weeds have been noticed by Col. Grant in the shales, otherwise they appear to be devoid of organisms.

The "Gray Band," however, contains a few poorly preserved casts of shells, besides several species of sea-weeds. The fossils are usually found crowded together on some portions of the surface of the sandstones, overlaid by more or less earthy partings, particularly at the junction with the overlying Clinton, or those beds that might perhaps be considered beds of passage.

The sea-weeds are the most common. *Arthrophycus harlani* is abundant at Grimsby. The branches of this organism is sometimes connected with lobed nodules, having the appearance of fruit pods; however, some palæontologists consider *Arthrophycus* as worm tracks, and, if this be the case, these lobed expansions are simply worm burrows at the end of the tracks.

A considerable number of undoubted worm tracks or Ichnites is also found. All the fossils consist of nothing more than casts in the sandstone.

The following meagre list of fossils has been obtained.

CATALOGUE OF MEDINA FOSSILS.

Genera and species. *Reference.*

Arthrophycus harlani ....Hall, 1852, Pal. N. Y., Vol. II.
Locality—Grimsby, Ont.

" " Fruit (?)......
Locality—Grimsby.

Palæophycus sp.....................
Locality—Hamilton and Grimsby.

Zaphrentis bilateralis ....Hall, 1852, Pal. N. Y., Vol. II
Locality—Hamilton and Grimsby.

Atrypa oblata ....Hall, 1852, Pal. N. Y., Vol. II.
Locality—Hamilton and Grimsby.

Modiolopsis orthonota...............Conrad, 1839, Ann. Rep. N. Y.
Locality—Hamilton.

" sp.....................
Locality—Dundas, Hamilton, and Grimsby.

Murchisonia subulata ....Conrad, 1842, Jour Acad. Nat. Sc.
Locality—Hamilton.

" *conoidea* ....Hall, 1852, Pal. N. Y., Vol. II.
Locality—Hamilton and Grimsby.

Pleurotomaria litorea...............Hall, 1852, Pal. N. Y., Vol. II.,
Locality—Hamilton and Grimsby.

" *pervetusta*............Conrad, 1838, Ann. Rep. N. Y.
Locailty—Hamilton and Grimsby.

Ichnites (several speeies)...........
Locality—Hamilton and Grimsby.

V.—CLINTON FORMATION.

In southern Herkimer County, N. Y., the Medina formation is wanting, and the Clinton rests on thin deposits of Oneida conglomerate, which itself dies out farther to the east. In the more eastern portions of the State of New York, where the Clinton series succeeds the Medina, it partakes of its lithological characteristics. However, as the Clinton extends westward its shales become intercalated with calcareous deposits that form a conspicuous feature. The calcareous beds increase in importance as the formatiom extends westward in the Province of Ontario, and at Hamilton they so nearly resemble those of the overlying Niagara, that the line of separation becomes almost arbitrary. The New York Geologists placed a hard layer of dolomite, containing remains of *Pentamerus*, and known as the "Pentamerus Band," as the upper bed of the Clinton of New York, while the Canadian Geological Survey considered it as the lowest bed of the Niagara series, which in our Province, it most nearly resembles. The latter division, between the Clinton and Niagara, I have adopted in this paper, if indeed, a division, except for convenience, should be made. In fact, the upper nine feet of the Clinton deposits at Hamilton might well be placed with the Niagara above. Nor are there any palæontological grounds of separation.

The Clinton group may be described as dolomitic shales, with numerous thin beds of argillo-arenaceous dolomites, some of which almost resemble impure sandstone. The indurated shales are generally of blue or dark gray, but in weathering they assume a red, brown or buff color. Many of the more calcareous bands are highly fossiliferous. About twenty feet from the top of the series there is a red or brown ferruginous calcareo-arenaceous rock, about eight feet thick, holding an abundance of casts of fossils, which are mostly of the genera *Modiolopsis* and *Lingula*.

It may be here remarked that none of the *Lamellibranchiate* shells retain any part of their original tests, while the *Lingulæ* have their shells well preserved, and often of a blue color.

This bed of red ferruginous rock is the representative of that peculiar bed of oolitic iron ore, called "Fossil Ore," forming a characteristic element of the Clinton group, extending from Wisconsin to New York, and thence along the Appalachian Chain to Tennessee and Alabama. In some places the "fossil

ore" is only represented by ferruginous stains on the rock. This iron matter came probably from the denudation of the extensive iron ore deposits, Huronian Age, just north of the Clinton sea, in what is now Michigan.

The lower nine feet of the Clinton beds are composed of argillaceous dolomites with shaly partings, which are sometimes bituminous. Some of these layers are so granular and arenaceous as almost to resemble sandstones. From the few fossils obtained here, these rocks may be considered as beds of passage from the Medina. Including the beds that I have placed as beds of passage at the base and those at the summit of the Clinton formation, the whole thickness at Hamilton is 94 feet, and at Dundas 88 feet.

In New York, on the Genesee River, the Clinton group has a thickness of 80 feet, consisting of calcareous shales with thin beds of shaly dolomite, together with the characteristic *Oolitic iron ore* bed.

In Ohio this formation is represented by salmon-colored dolomitic limestones which vary in thickness from 15 to 40 feet.

As has been noticed, the Clinton deposits lithologically resemble those of the Medina, in eastern New York, while in the western part of the State, they approximate to the overlying Niagara. This resemblance is still greater in Canada, where much of the shaly matter is replaced by calcareous rocks, and in Ohio, according to the Geological Survey of that State, the argillaceous beds are wholly replaced by limestones. Again those differences in the fossils which characterise the respective Clinton and Niagara formations in eastern New York largely disappear in the more western deposits. In Canada the palæontological differences seem to be due to the state of preservation of organic remains in the shales and limestones respectively; for the forms which occur in the Clinton limestones are generally found in the calcareous rocks of the overlying Niagara, whilst the principal differences are in those fossils preserved in the Clinton shales, which are not represented above by similar rocks. In fact there is no more variation in the fossils found in the Clinton and Niagara formations at Hamilton than there is between those of the Niagara "Chert Bed" at Hamilton and of the upper layers at Barton, five miles distant.

Professor Orton found that the Clinton of Ohio contains pebbles of the "Cincinnati (Hudson River) limestones." In

the south-western part of that State the deposits under consideration rest either on rocks of the Cincinnati group, or on the thin development of Medina shales (which are from ten to twenty feet thick). The conglomerates show that the underlying formations of the Cambro-Silurian Age had been hardened and uplifted into cliffs and shore lines before the commencement and deposition of the sediments in the seas of the Clinton epoch. At this time the Canadian Sea was one of shallow water. At Dundas, Hamilton and elsewhere, various thin hard beds from the base to the summit of the formation have their surfaces covered with ripple marks. As the muddy sediments, which filled up the northern and north-eastern portion of the Medina Sea, were principally derived from the *débris* of the Utica and Hudson River groups of the Canadian highlands, so also the Clinton shales appear to have been derived from the same source; but these muds gradually gave place to the organic limestone in the western portion of the Clinton seas.

Organic Remains in the Clinton Formation.—Recently an interesting group of small fossils was discovered by George J. Hinde, Esq., F.G.S., in Glen Spencer, Dundas. These organisms appear as black shining chitinous objects on the surface of the stone, usually about the twelfth of an inch in length or less, and were recognized by Mr. Hinde as the jaws of annelids or worms. They will be found described and figured in the August number of the "Quarterly Journal of the Geological Society of London," for 1879. Excepting the jaws, no portions of the heads of the animals were found. The following is a catalogue of Mr. Hinde's species:

FROM THE CLINTON BEDS.

Eunicites clintonensis.
Eunicites coronatus.
Eunicites chiromorphus.
Œnonites amplus.
Œnonites fragilis.
Arabellites elegans.
Lumbriconereites basilis.
Lumbriconereites triangularis.
Lumbriconereites armatus.
Glycerites calceolus.

Besides these, he describes three species from the Niagara formation; and as I have not the specimens in my collection, I will include them here with the Clinton species:

Œnonites? infrequens.
Arabellites similis.
Staurocephalites niagarensis.

The following is a catalogue of the Clinton fossils obtained at Hamilton and Dundas. This catalogue does not contain all the species that are included with the Niagara group proper, which Col. Grant and myself have found in the so-called Clinton beds, but only the more conspicuous species, or those not found higher up at Hamilton.

CATALOGUE OF CLINTON FOSSILS OCCURRING AT HAMILTON.

GENERA AND SPECIES.	REFERENCE.
Buthotrephis gracilis	Hall, Palæont, N.Y., 1852.
" " var. *crassa*	" " "
" *palmata*	" " "
Roots of various *Algæ*	" " "
Stromatopora sp.	
Conophyllum niagarense	Hall, Palæont, N.Y., 1852.
Monticulipora lycoperdon	Say, " 1847.
Zaphrentis bilateralis	Hall, Palæont, N.Y., 1852.
Graptolithus clintonensis	" " "
Retiolites venosus	" " "
Palæaster granti	Spencer, Niag. Foss. 1882.
Eucalyptocrinus decorus	Phillips, Murch., Sil. Syst., 1839.
Helopora fragilis	Hall, Palæont, N.Y., 1852.
Clathropora frondosa	" " "
Fenestella prisca	Londsdale, Murch., Sil. Syst., 1839.
" *parvulipora*	Hall, 20th Rept. of Regents, N.Y., 1875.
" *tenuis*	Hall, Palæont, N.Y., 1852.
" *bicornis*	Spencer, n. s. Niagara Fossils, 1882.
Polypora incepta	Hall, Palæont, N.Y., 1852.
Rhinopora venosa	Spencer, n. s. Niagara Fossils, 1882.
Retepora angulata	Hall, Palæont, N.Y., 1852.
Trematopora tuberculosa	" " "
Merista cylindrica (?)	" " "
Athyris (*Meristella*) *naviformis*	" " "
Strophomena rhomboidalis	Wahlenberg, Act. Soc. Sci. Upsal, 1821
Orthis elegantula	Dolman, 1837.
Lingula oblonga	Conrad, Ann. Rep., N.Y., 1839.
" *oblala*	Hall, Palæont, N.Y.. 1852.
Posodonia (?) *alata*	" " "
Posodonomya (?) *rhomboidea*	" " "
Orthonota sp. (?)	
Modiolopsis, sev'l undetm'd spc's.	
Platyostoma niagarense	Hall, Palæont, N.Y., 1852.
" sp.	
Orthoceras clavatum	Hall, Palæont, N.Y., 1852.
Oncoceras subrectum	" " "
Conularia niagarensis	" " "
Tentaculites distans	" " "
Rusichnites bilobatus	
Ichnites, four undeterm'd spec's.	

VI.—NIAGARA FORMATION.

Topography and Distribution.—Overlying the Clinton formation, the most important member of the series—the Niagara (proper)—is much more widely developed than the lower portions of the group which are largely made up of mechanical deposits. Owing to the hard limestones of the Niagara epoch surmounting several hundred feet of soft Medina and Clinton shaly rocks, it forms a conspicuous feature in the country—the summit of the Niagara escarpment—as along its northern and north-eastern margins, the softer material forming the base of ridge has been removed by erosion, leaving abrupt cliffs.

The most eastern exposures of this formation in New York are near the town of Catskill, on the Hudson River. From this place it extends westward through the central and western parts of the State, forming the bold slopes, a few miles south of, and parallel to, Lake Ontario. Entering Canada at the Niagara River, its direction is westward. nearly parallel with its *strike*, as far as Dundas, at the extreme western end of Lake Ontario. Here the range of hills changes its course and extends to Cape Hurd, and thence through Manitoulin and Cockburn Islands. The range of hills south of the lake, as we have noticed, is about 400 feet high and generally has an abrupt face. However, from Dundas to Georgian Bay, although the country is of a higher altitude, the features are less broken on their eastern side, as they recede from Lake Ontario.

The southern portion of the basin of Lake Ontario is excavated in Medina shales, while its northern side is scooped out of the various rocks of the Hudson River, and the shales of the Utica formation, which once formed the margin of the old sea in the Niagara period.

From the northern end of Lake Huron the Niagara formation extends into Drummond Island, and thence along the whole northern and western shores of Lake Michigan. Again, the margin of the seas in this period abutted against the Appalachian chain as far south as Tennessee, as is shown by the remains of their old deposits. The large island of the "Cincinnati Arch" formed part of the barrier at the southern margin of the Mediterranean Sea, which extended over a region of thirteen degrees of longitude and eight of latitude, in the Niagara period, or, we may say, in the Silurian age.

In Canada many streams cut through the rocks of the region under consideration, and give fine exposures of their geological structure. The streams invariably excavate picturesque glens, at the head of which are usually cascades in magnitude from the Falls of Niagara to others forming a mere series of rapids.

Development—The best exposures of the Niagara formation in the State of New York are at Lockport, Rochester and Niagara River. It attains a thickness of 264 feet in that State. In Canada the upper portion of the series is so denuded in the neighbourhood of Lake Ontario, that it is impossible to get a complete section; and even many miles away where it passes into the overlying Guelph formation, as near Rockwood the line of junction is generally obscured by drift.

At Hamilton, by level measurements, a section of the lower 52 feet (being beds from 7 to 12 of Section III) was made by Mr. S. D. Mills and myself, between the exposure at the head of James street and the "Jolly Cut" road, a half mile to the east. Here the escarpment averages 390 feet in height above the lake. The cherty dolomites (No. 12 of Sections) form the capping stratum of the "Mountain." Along the Sydenham road (section II), the section, composed of the same beds, measured 60 feet (seven feet more of the "Chert bed" is exposed here than at Hamilton). Again, at the junction of Glen Spencer with Glen Webster, the same "Chert beds" form the capping stratum of the cliffs, and here the Niagara beds are a little thicker than elsewhere. However, on the eastern side of these ravines there is an additional exposure of 104 feet near the "Peak," which has not been removod by denudation, thus giving a maximum thickness of 169 feet at Dundas. However, by measuring the section at Albion Falls, and then levelling up Rosseaux Creek and along the strike of the formation to Carpenter's Limekilns, on Lot 15, and Range VI, Barton, two miles south of the brow of the "Mountain," at Hamilton, I succeeded in measuring a section of 198 feet from the base of the Niagara (proper). The height of the last station is 480 feet above the lake, and in addition the rocks are covered with five feet of soil, at the Church, on the same lot. Here the rocks have their surfaces grooved with ice action. It may be remarked that the capping bed in this place is almost wholly made up of the remains of *Stromatopora*.

This last section carries us to a higher horizon than any other measurable, yet the highest members of the series is still beyond our reach, being covered by the drift over the gently sloping country. However, if we follow the line of strike westward, and take the levels here, and at the nearest exposures of the Guelph formation, at Galt (which is a few miles north of the line of strike of the Barton Beds) and make allowance for dip, it would approximately be found that the unexposed upper beds of the Niagara formation reach to an additional 80 or 100 feet in thickness.

According to the reports of the Geological Survey of Ohio, the formation has a thickness of 275 feet in Highland county, and probably 350 feet in the northern part of the State. The Canadian Geological Survey estimated the whole thickness at 450 feet in the neighbourhood of Cape Hurd, if the dip were uniform.

Thus we see that from the western part of New York to Ohio there is no great variation in the thickness of the Niagara deposits, where the surface is not removed by erosion, and we may fairly place the accumulations in the Canadian portion of the Niagara sea at 280 feet.

Not only is the deposition of the whole series literally uniform, but there are certain strata which are recognizable as constant over the region under consideration. Of these, the most conspicuous are the "Chert bed" (No. 12 of sections), and a thick compact bed of light gray dolomite (varying from four-and-a-half to five-and-a-half feet thick, and numbered 8 in the sections). It was from taking the levels of this last bed at Albion Falls, Hamilton and Dundas, that I estimated the dip at 25·5 feet in the mile, in direction, about twenty degrees west of south. Locally, however, I found the dip sometimes amounting to 37 feet. The distances of the sides of the triangle formed by the three stations above named, were taken from the large county map. The calculation agreed closely with that made from the approximate height of the base of the formation at Limehouse, and that known at Dundas, and taking the direction of the dip to be that found by the above mentioned triangle.

At Limehouse the surfaces of some of the strata are almost as irregular as those of the Medina at Dundas. On the north side of the Dundas Valley the rocks in some places are almost horizontal, but again they are found dipping a few feet in the mile to the northward. This being the case, generally, would make

the Dundas Valley an anticlinal valley, with the slope in each side less than one degree.

Character of the Rocks.—In New York the lower part of the Niagara formation is represented by 80 feet of dark fossiliferous calcareo-argillaceous shales; at Thorold, Ontario, these are much thinner, and at Hamilton and Dundas they are not represented by more than from six to ten feet of muddy sediments (No. 9 of sections), whose upper portions graduate into more calcareous beds. The general character of the series at the western end of Lake Ontario may be represented by the following section in descending order:

(*a*) Thin beds of dark (often limestone and earthy) dolomites, with shaly partings. Some layers are fossiliferous..	132 feet.
(*b*) Thin beds of light-colored dolomitic rocks, containing an abundance of cherty nodules; fossiliferous.............	19 feet.
(*c*) Dark blue or gray shaly dolomites; fossiliferous.....	16 feet.
(*d*) Dolomitic compact shales........................	10 feet.
(*e*) Light drab crystalline compact dolomite, in one bed.	5 feet.
(*f*) Dark gray compact dolomite, in moderately thick beds, the lowest of which contains *Pentamerus*................	10 feet.

At Limehouse, only the lower beds are exposed near their junction with the underlying Clinton rocks. Here the deposits consist of light colored dolomites, of uniform texture in thick compact beds, holding only casts of fossils.

The representatives of this formation in Ohio consist of the Dayton limestone of five feet in thickness, succeeded by 60 feet of shales, over which there are 180 feet of limestones, and in Highland County the series is surmounted by 30 feet of sandstone. In referring to these western beds, we find included the Cedarville limestones, beds which are considered of the same horizon as the Guelph dolomites.

The color of the limestones becomes lighter on going westward, especially after turning a point at Dundas, which formed a right-angled prominent cape in the sea of the Niagara period. Even within a few miles, near Dundas, one can notice the lighter color of the purer calcareous deposits, and at Limehouse, to the north-west of the old cape, coloring matter and shale are almost wanting.

Composition and Chemical Analysis of the Limestones.—The Niagara limestones, in Canada, consist almost entirely of the double carbonates of lime and magnesia, with a varying per-

centage of clay, free sand and silicates of the alkaline earths. Sometimes, however, there is an excess of carbonate of lime over what is required for the production of the double carbonate. Under the microscope this excess of calcite is seen occupying the small spaces between the more uniformly crystalline particles of dolomite. The quantity of iron is generally small, and present in the state of protoxide, though in some of the beds it occurs as pyrites. Bituminous coloring matter is present in many of the strata, and in a number of beds it occasionally fills small cavities. There are but few beds east of Dundas which have not a considerable quantity of earthy matter present.

The shales in this region differ from limestones only in the larger quantity of clay and other silicates present in place of the calcareous matter, for they all contain a large percentage of carbonate. In fact many of the beds are of an intermediate character, that it is difficult to decide whether to call them earthy limestones or calcareous shales. Of several beds at Hamilton, I made the chemical analyses, together with a microscopic examination. A few of the results are here given.

Analysis I.—The sample was taken from near the base of the series (No. 7 of section) at the "Jolly Cut," Hamilton. Under the microscope only a mass of transparent particles of dolomite, separated by dark amorphous earthy matter, was visible.

Calcium carbonate	46·6
Magnesium carbonate	36·5
Ferrous carbonate	1·7
Calcium silicate } Magnesium silicate }	3·6
Alumina	4·4
Silica	6·7
Moisture	0·3
	99·8

Analysis II.—This analysis represents the composition of the thick bed of light gray dolomite (No. 8 of section) at the "Jolly Cut," Hamilton. The rock is highly crystalline, and shows crystalline plates of crinoids and shells, but seldom contains complete casts of fossils. Under the microscope it shows a mass of crystalline semi-transparent particles of dolomite, full of small cavities, which are often lined or filled with pure calcite, consequently the carbonate of lime is in excess. This bed contains

many large cavities of several inches extent filled with foreign minerals, which will be noticed further on.

Calcium carbonate	59·7
Magnesium carbonate	38 2
Alumina and oxide of iron	1·5
Silica	0·4
	99·8

Analysis III.—The bed from which this sample was taken is about five feet above No. 8 of section, and is one of the harder and more compact layers (No. 9 of section) of that portion of the geological horizon which I have identified as the Niagara shales at the "Jolly Cut," Hamilton. It is said to produce hydraulic cement, but if so it would be of inferior quality.

Calcium carbonate	33·8
Magnesium carbonate	25·2
Calcium silicate	6·6
Magnesium silicate	2·7
Alumina	5·1
Ferrous carbonate	1·8
Ferric oxide	1·6
Ferrous disulphide (Pyrites)	1·9
Silica	20·0
	98·7

Analysis IV.—The sample for this analysis was obtained from the "Chert bed" (No. 12 of sections). The portion taken was free from cherty concretions, as these portions would be nearly made up of pure silica. Under the microscope there was only the usual crystalline structure of the dolomitic particles separated by dark earthy matter.

Calcium carbonate	46·6
Magnesium carbonate	38·9
Calcium silicate } Magnesium silicate }	2·8
Ferrous oxide	0·8
Alumina	2·4
Silica	9·3
	100·8

A large number of other specimens were examined under the microscope, but they were all of essentially the same structure,

and more or less homogeneous, except some of the more flaggy beds where the crystalline calcareous matter was deposited in alternating layers with the more earthy matter.

As many of the dark beds are colored with bituminous matter some of the calcareous rocks burn to a white lime.

By way of comparing the Niagara rocks in Canada, with those in Ohio, I here quote several analyses of the limestones of this formation in that State, as made by Professor Wormley.

	I.	II.	III.	IV.	V.
Calcium carbonate........	85.50	54.45	50.90	55.50	54.20
Magnesium carbonate.....	11.16	42.23	39.77	43.28	44.80
Calcic & magnesic silicates.	——	——	7.07	——	——
Alumina and iron.........	2.00	0.40	1.19	0.30	0.10
Siliceous matter..........	2.20	2.00	.70	0.60	0.80
	100.86	99.08	99.63	99.68	99.90

Analysis of the Shales.—As noticed before, the Niagara shales are analogous to the limestones where the calcareous matter is partly replaced by argillaceous material.

Analysis V.—The sample here examined was from one of the most shaly layers (No 9 of the sections) of the shaly portion of the formation at the "Jolly Cut," Hamilton. Under the microscope the earthy matter seemed to be held together by the crystalline particles of dolomite.

Calcium carbonate..................	29·4
Magnesium carbonate................	23·9
Calcium silicate } Magnesium silicate }	4·5
Ferrous oxide......................	0·9
Ferric oxide.......................	1·6
Alumina............................	15·0
Silica.............................	24·4
	99·7

The following analysis of the Niagara shale of Ohio was made by Professor Wormley:

Calcium carbonate..................	34·00
Magnesium carbonate................	30·87
Calcium silicate	8·48
Alumina and iron...................	8·40
Silica.............................	12.21
Water (combined)...................	5.40
	99·36

Source of the Mechanical Deposits.—From the character of the rocks and their distribution in the Niagara period, as seen by glancing at a map of the Palæozoic Geography of America, we see that the mechanical sediments (shaly matter), of the northern and north-eastern margin of the old inland sea came principally from the Canadian highlands. The Hudson River group formed the shore line of most places, from the beginning of the Medina epoch, both in New York and Canada as well as along the "Cincinnati Arch." The eastern portion of the Province of Ontario was covered by the limestones of the *Trenton group;* the central portion, by the great accumulation of dark *Utica shales*, and these last by shales with intercalated limestones and sandstones of the *Hudson epoch*, extending along their western margin, and forming the north-eastern shores of the sea, as developed at the beginning of the Silurian Age (proper), in the region from what is now the western end of Lake Ontario to Georgian Bay.

It may be noticed that the limit of the Utica shales is not west of the meridian of the Niagara River. At the close of the Cambro-Silurian Age the deposits belonging to that period extended much farther southward than at present, probably to a latitude not far north of the southern shores of Lake Ontario—at least, in its eastern extension. It was in this soft material that the lake basin was subsequently excavated, the erosion having extended but a few miles into the Niagara limestones, and their underlying shales, and left the escarpment in bold relief.

Now, on examining the sediments south of the Canadian shores of those days, we find only thin beds of shale in the more eastern deposits, but these gradually thicken in extending westward, until, in the neighbourhood of Rochester, they amount to 80 feet (the place being south of the shores composed of Utica shale). Again, the shales begin to thin out at Thorold, Ontario, where they amount to fifty feet, while thirty miles westward, as at Dundas, they are only a few feet thick, and almost entirely disappear after turning the ancient Cape and passing west of the line from this town to Lake Huron, as the waters, there, were protected from the muddy eastern currents. The northern end of the sea was not subjected to the influx of mud to any extent, as in that direction the shores were adjacent to the old crystalline Huronian and other mountains. However, more shales make their appearance in the western area, having been derived

from the somewhat shaly Hudson group of the "Cincinnati Arch," or, perhaps, from the margins of Medina shales that may have existed on the south-western island coast. Of course in the eastern portion of the old sea much shale came from the disintegrations of the other Appalachian highlands. During the Medina epoch, in this region, five hundred feet of shales were carried down into the eastern or north-eastern portion of the sea, while only twenty feet of sediments were deposited to the south-westward.

Again, the turbid waters in the Clinton epoch interrupted periodically the growth of impure organic calcareous beds, while the western portion of the old sea was nearly free from the influx of mud.

Character of the Marine Life and Origin of the Limestones.—We have observed that the greater portion of the upper beds of the Niagara epoch in New York, almost all in Ontario, and the greater portion in Ohio, together with a considerable portion of the Clinton epoch in Canada, and all of that horizon in the more south-western State, are made up of dolomitic limestones of a greater or less degree of purity. Let us examine into the condition of the seas and of the life that flourished at this time.

During the earlier days of the Mediterranean sea in the Niagara epoch, in the eastern and south-western areas, the waters were of a turbid character, though freer from earthy matter in its northern extension. Later, however, and during the greater period of its existence, only a small amount of shaly sediment was occasionally carried down, thus producing favorable conditions for the growth of marine life.

The limestones in Canada are of a highly crystalline texture, and consequently most of the traces of the organisms that contributed to their original formation are obliterated. Out of numerous specimens of rocks examined under the microscope, none show any organic structure, except some parts of those beds containing *sponges* or *stromatopora*, with here and there a place where a stray fossil has escaped obliteration, in the re-crystalization of the calcareous mud. In fact, as regards both shells and corals, there is seldom anything left more than their casts preserved in the stone. Even when, by chance, a portion of the original bed has escaped obliteration, it has become highly crystalline. Here and there is an exception to this statement, as in the case of the phosphatic shells, *Lingula* and *Discina*, in which

frequently portions of the original tests remain. In the region under consideration nearly 200 species of fossils have been obtained from the beds of the Niagara group, yet the collector may spend days and obtain a mere handful of specimens to reward him for his trouble.

It may be noticed here that there is a bed near the top of the series at Dundas, several feet thick, that appears to be made up of breccia, the fragments being derived from older portions of the adjacent rocks.

During the long period required for the deposition of the limestones, the character of the organisms which inhabited the sea was subject to some important changes. One of these conspicuous periods has left its stamp in the "Chert beds," which are classed as No. 12 of the sections. The average thickness of this series of thin beds of limestone, filled with numerous concretions of cherty material, is eighteen or nineteen feet. The limestones are dolomites, as is shown by the previous analysis. By far the greater proportion of concretions show no organic structure, but yet, such large numbers when broken, show the internal sections of sponges, which mostly belong to the genera of *Astylospongia* and *Aulocopina*, that the origin of the siliceous nodules is at once apparent. On some portions of the brow of the escarpment, both at Hamilton and Dundas, these beds form the summit, and as the surface soil of the rocks weather, just beneath what is only a few inches of soil, the complete forms of the sponges become exposed by the action of the frost and of the plough. The sponge life was very considerable, that it could have afforded a sufficient source for so much soluble silica as to have produced the enormous amount of chert found in these beds. We know also that the variety of species was considerable. Nor was the sponge-life all that adorned the sea at that time. These beds are by far the richest in variety of species, from the lowest radiates to the higher types of life that are found in the Niagara series. It is also worthy of notice that it is in this small series that the greater portion of the rich *Graptolite fauna*, to be described in a succeeding paper, is found.

Just beneath these beds (No. 11 and 10) which are more shaly in character (of which the upper strata are known as "blue building beds"), we find our greatest number of *Tribolites* together with the high-type Crustacean, *Pterogotus canadensis* (Dawson), recently discovered by Col. Grant.

Another conspicuous epoch in the history of the ancient sea is marked by the great bed of dolomite (No. 8 of section). At no time was the sea so free from the influx of mechanical sediments. This bed with a thickness of about five feet forms an enduring monument for the myriads of crinoids whose remains most largely led to its formation, although subsequently it has absorbed magnesia, which in the re-crystallization of its molecules has obliterated all but the fragments of the original segments of their stems.

Another noticeable change in the rock-making organisms is found in a bed of dolomitic rock two and a half feet thick, almost literally filled with the remains of three or four species of *Stromatopora*. This stratum is near the surface bed at Carpenter's Limekilns, (Range VI, lot 15 of Barton) about three miles south of the centre of the city of Hamilton.

Besides the remains of life, as shown in these few more conspicuous beds, we find throughout the whole Niagara epoch that Bryozoons were numerous; Crinoids were abundant (in places, as at Grimsby, where some of the beds consist simply of masses of these stems). Corals were dominant in some localities, and Mollusks of every class were largely represented.

The Niagara limestones have been largely derived from broken shells, corals and other calcareous organisms, but subsequently the calcareous matter has combined with, or a portion of it has been replaced by, magnesia which had been precipitated amongst the comminuted organisms.

Henry C. Sorby, Esq., F.R.S., President of the Geological Society of London, (Q.J.G.S., May, 1879,) has shown that the condition in which calcareous matter is present in the structure of shells, or of allied forms of life, has much to do with the subsequent preservation of their remains in the rock, on the crystallization of their particles into solid limestones.

The principal condition in which lime is present in calcareous organisms is as the carbonate, either in the form of calcite or aragonite. However, there are some structures like the *Lingula*, where the lime occurs, as the phosphate, the same as in bones. The phosphate of lime is less apt to change its molecular condition than the carbonate, and, as a result, the shells of that material, or partially of it, are generally better preserved in the fossil condition than those of the carbonate. But these phosphatic shells have not contributed to any extent in the formation of the Niagara limestones.

The crystalline form of aragonite may be considered as an abnormal form of carbonate of lime, and Mr. Sorby shows that under various circumstances, it is easily resolved into the more stable form of calcite. whilst the carbonate, in the crystalline form of calcite, cannot be changed by any known process into that of aragonite. These two minerals form the principal constituents of the tests of shells—in some classes the aragonite being present, in others the calcite, and again in others the inner layer may be of aragonite and the outer of calcite, or *vice versa*.

Mr. Sorby gives the following classification of the mineral composition of the different orders of shells:

(*a*) *Crustacea.*—The mineral matter of crustaceans consists of calcite hardened on the surface with phosphate of lime.

(*b*) *Cephalopoda*—These shells are made up of aragonite together with a small amount of phosphate of lime.

(*c*) *Gasteropoda.*—In most of these genera the shell is wholly made up of aragonite, but in some the outer layer consists of calcite.

(*d*) *Lamellibranchiata.*—In many species of this group the tests are composed wholly of aragonite, in some entirely of calcite, whilst other shells have their inner layer of one material and the outer of the other.

(*e*) *Brachiopoda*, are composed wholly of calcite.

(*f*) *Echinodermata.*—Here the mineral matter is calcite.

(*g*) *Polyzoa* are composed of various mixtures of both minerals.

(*h*) *Hydroida and true corals* are made up of aragonite—the former class having a small quantity of phosphate of lime.

(*i*) *Foraminifera* are probably composed of calcite.

The removal of the organic matter holding the particles of the shell together disturbs the stability of the structure, and not only causes it to crumble by the disintegration along the lines between the different minute crystals, but also hastens a subsequent re-arrangement of the molecules into larger and less constrâined crystals. Especially is this the case with fragments of aragonite which soon take the form of calcite, as is shown by the experiment of Mr. Sorby, where powdered coral (aragonite) kept for only a few weeks in water began to change into the condition of calcite. Moreover, this is not only an experimental test under favorable circumstances, but it is found that the modern limestones now forming about some of the West Indian Islands, have in places entirely lost or are losing the natural forms of the organic fragments of which they are composed. Again, the

disintegrated fragments, which are assuming the more crystalline condition have their interspaces filled with carbonate of lime dissolved in the water, which was probably derived from the original material of the shells.

If the organic remains be included in a matrix of the same color, not only the form but also the certainty of its former presence in any position is apt to be lost. Especially is this the case with the corals and shells which are composed of aragonite. However, if the surfaces of the organisms were covered by thin layers of some foreign matter, as pyrites or mud, the former may still be preserved, but the place occupied by the structure will be found to have a more highly crystalline structure than the matrix itself, as the carbonate of lime of the shells, not having a great surface exposed by being broken into fragments, has more time for gradual re-arrangement of molecules, and, consequently, larger and more perfect crystalline forms are produced. This is found to be particularly the case with Lamellibranchiate shells (aragonite) in the rocks of the Niagara group at Hamilton, where only the remains of casts, procured in the manner just described are to be found, although some beds indicate that they were originally made up of a mass of these shells. The best preserved fragments of organic structure in our rocks are stems of crinoids, but these are generally re-crystallized, although they were even at first in the forms of small crystals of calcite.

The corals generally have become silicified but the forms are so far changed as to show that the original calcareous matter was re-crystallized before its replacement with silica was accomplished.

Some of the Graptolites are well preserved owing to the large amount of corneous matter that may have arrested molecular change. From obscure casts some of the beds of limestones appear to have been derived from Orthocerata. Brachiopods are the commonest fossils retaining any of their original appearance. Polyzoa are fairly preserved, especially in the "Chert bed," where also a few Gasteropoda retain their calcareous structure. In fact nearly all the fossils are better preserved in the "Chert bed" than elsewhere. This fact may in some way be accounted for owing to the presence of soluble silica derived from the sponges having cemented the calcareous plates together at the time when the animal matter of the structures was being gradually removed, for many of the fossils seem to be saturated with siliceous material.

The obliteration of the original calcareous organisms was completed by the physical changes which resulted in the combination of the calcareous matter, with the magnesian carbonate and the subsequent re-crystallization in the form of the double salt. According to the experiments of Mr. Sorby this was effected by the magnesia replacing a portion of the lime. But Dr. Sterry Hunt, many years ago, announced that, as indicated by his experiments, all magnesian limestones are derived from the precipitation of both carbonates simultaneously in an inland salt sea. At least as far as the Niagara dolomites are concerned, the calcareous organisms have played a most important part in furnishing calcareous matter, although the magnesian salt may have been exclusively derived from the evaporation of the waters in the immense inland Niagara waters, for at Grimbsy a bed of this dolomite shows its derivation almost exclusively from crinoids, and at Hamilton a similar bed in a more highly crystalline state, and filled with pores from the shrinkage, forms a marked feature of the series.

In the molecular change a condensation in volume would occur, thereby leaving the rock porous and permitting the carbonate of lime of the calcareous fossils to be washed out; as illustrated in the great bed of dolomite (No. 8 of sections) and some other beds, where the cavities have not been subsequently filled with argillaceous mud.

As a further illustration of the subsequent removal of the material of the shells by water, we need only go a little beyond the present region of study to the Guelph dolomites, where are numerous casts of shells in the porous stone, with the whole shell and its filling removed, thus leaving numerous cavities in the rock.

Dr. Hunt has conducted a series of experiments which throw light on the origin of dolomites. In lake basins where there is a considerable evaporation going on, the waters containing bicarbonate of soda cause the separation of all the lime as carbonate, and the formation of soluble bicarbonate of magnesia, which, subsequently on evaporation, separates in the hydrated form. The salts mingled together under pressure and heat will combine to form double carbonates. From the disintegration of feldspars and other rocks, an abundance of carbonates of soda, lime and magnesia, are constantly being brought down by streams and emptied into the sea basins. These chemical precipitates mixing

with' (and replacing according to Sorby) a portion of the calcareous sand derived from the organic remains in this region, have probably in a great degree given rise to our Niagara limestones, all of which are more or less of the character of true dolomites, but where some contain mechanical *detritus* as siliceous and argillaceous mud.

From this examination of the character of the limestones of the Niagara group, it is not surprising that there is such a paucity of fossils in this great development of rocks so largely composed of their remains. In very many strata I have found no fossils whatever, and even in those where they are most abundant, one is rewarded only after a long patient search. Yet, with all these difficulties, the geologist may collect in the region of our study a large number of species, of which there are catalogues under those parts of this paper on the Medina and Clinton epochs, and a still larger list at the end of this portion of the paper on the Niagara epoch proper.

VII.—MINERALS OCCURRING IN THE NIAGARA GROUP.

Excepting the beds of stone fit for building purposes and for burning to lime, there are no minerals about the western end of Lake Ontario of economic importance. However, many years ago some futile attempts were made south of the village of Beamsville to work a small "find" of galena. The only sandstones fit for building purposes is the "Gray band" of the Medina formation. Blocks of this stone of any dimension that can be handled are obtainable. This stone has been extensively worked at Dundas, Hamilton, Grimsby and Beamsville. A great drawback in quarrying this material is that it can only be procured along the edge of the escarpment, and requires a vast amount of the shaly rocks of the Clinton formation to be removed, and even then the supply is of a limited quantity. The stone is very tough and hard on tools. I am informed that this rock was formerly manufactured into grindstones. The majority of the beds of limestone are too thin, or inferior, for anything more than the roughest building material. However, there is a sufficient number of layers to supply an abundance of building material of which the handsomest is obtained from the great dolomite (No. 8) and the subjacent beds. In fact all the beds belonging to the Niagara series, that will at all admit of use, are quarried at Hamilton, and the broken material of the "Chert band" and

other layers is used for road metal, and only the more shaly limestones are rejected. The "Blue-Building beds," although somewhat earthy, form fair building material. At the old quarry along Rosseaux Creek, and elsewhere, in the higher portion of the series, good, fairly thick blocks of dolomite can be obtained

Though the limestones are generally rather dark, they burn to white lime, as the coloring is derived from organic matter. The principal limekilns are supplied from the highest beds of the Niagara series in the region of Hamilton and Dundas, while at Limehouse, on the Grand Trunk Railway, the lower beds are light colored, rather pure, and form excellent lime—Toronto and many other places being supplied with immense quantities of the product of these kilns. Some of the beds also burn to hydraulic cement.

However, there are interesting minerals in this region, other than those which can be turned to use in the arts. The first of these minerals that we will notice is *epsomite*. This mineral occurs on both sides of Glen Spencer. It is found as an efflorescence on the edges of the Niagara shales which are protected by overhanging thick beds of dolomite. This salt has arisen from the disintegration of the adjacent dolomitic beds and the action of decomposing pyrites. In various other protected places this efflorescence is seen, but it does not consist of pure *epsomite* being mixed with carbonate of lime, carbonate of iron, sand and clay.

In the five foot bed of dolomite (No. 8) fine cabinet specimens of *selenite* and crystalline *barite* can be obtained. Also massive *gypsum*, handsome crystals of *calcite* (variety of dog-tooth spar), *celestite* and *quartz* in small crystals, as well as *iron pyrites* are found. Many of the cavities when broken open are found to be filled with alkaline waters. In one of the Clinton beds, east of the "Jolly Cut" road, I have found fine red and green crystals of *barite*. However, the handsomest specimens were obtained in Carpenter's Quarry, on lot 7, Range VII, of Barton, not now worked. Fine specimens of crystallized *dolomite* (pearl spar), *calcite* (in large scalene dodecahedrons, and in other modifications of rhombohedrons), *blende*, *pyrites*, *galena*, purple, smoky and yellow *fluorite* in fine cubes, and several forms of *bituminous matter*, both liquid and solid (a variety of which was elastic) were found in considerable quantities filling the cavities of the rock, and often lining what were once crystallites. It was

in beds of similar horizon at Beamsville that the galena was found and worked many years ago. The horizon of the beds is from 130 to 145 feet above the base of the Niagara in the neighbourhood of Hamilton.

In numerous places mineral waters are found. These are of two classes—alkaline and sulphuretted waters. Of the former class there are numerous springs along the sides of the escarpment. Similar waters have also been obtained in various wells that have been bored to a considerable depth. One of these wells was bored nearly, or perhaps, quite through the Medina shales at the Ontario Oil Refinery, east of Hamilton. The water of this place, I analysed in 1871.

Sodium chloride	2·28
Magnesium chloride	0·60
Calcium Chloride	1·67
Potassium chloride	a trace
Calcium sulphate	0·20
Residue	·10
Water	94·90
	99·75

Another of these mineral waters was obtained at a depth of 1009 feet in Cambro-Silurian beds from the Artesian well at the Royal Hotel, Hamilton. The following analysis was made in 1870:

Sodium chloride	6·3711
Magnesium chloride	1·2723
Potassium chloride	traces
Calcium chloride	5·2723
Calcium Sulphate	·1167
Silica, iron, carbonic acid, iodine and bromine	traces
Water	86·9676
	100·0000

Unfortunately the record of this well was burned, although a little of the saline water still remains in my possession.

Of the second class—sulphuretted waters—we find a few springs, the principal being at Mount Albion, and at Sulphur Springs, Ancaster. One of the old springs near Mount Albion is now dried up. From others in this place the supply of gas has continued to be evolved for many years, and three jets of this gas, essentially sulphuretted hydrogen, are used to light Albion

Mills; the proprietor having built a reservoir of hydraulic cement over the spring. At "Sulphur Springs," Ancaster, the amount of gas is not so large, and the supply is scarcely more than enough to saturate the water, from which the sulphur is precipitated on exposure to the air. In both of these localities the gas arises from decomposing pyrites in the surrounding rocks.

VIII.—CATALOGUE OF NIAGARA FOSSILS FROM CANADIAN LOCALITIES.

In the following catalogue I have endeavoured to give a full list of all the fossils that have been discovered in the region under consideration. As no extensive Canadian catalogue has been published, I have been compelled to depend largely on my own collection, many species of which have been presented to me by Col. Grant. A few of the included species are not in my collection, having years before been sent away from the region by the collectors, of whom Col. Grant is the most indefatigable. The best collection of *Sponges* and *Stromatopora* is that of Mr. A. E. Walker. Of the former group several species have remained undescribed. Some of the species, including most of the *Graptolite family*, are the TYPE SPECIMENS, descriptions of which are about to be published. Had Col. Grant retained all his own collection, he would have been able, no doubt, to have considerably swelled my list.

The best localities at Hamilton for collecting fossils are at the "Jolly Cut," and in the adjacent openings in the quarries along the sides of the "Mountain," both east and west of this place. Also, in the gorges at the heads of James and Queen streets; at the "Bluff," near the city reservoir; along the Hamilton and North-Western Railway to the summit of the hills; in the ravines near Mount Albion; on lots 4 and 5, Range VII, of Barton, along the Rosseaux Creek; and on lot 15, Range VI, of the same township. At Dundas, the various glens form the best localities, as well as Sydenham road. At Grimbsy the richest fauna is found up the "Ravine," where the fossils are in a better state of preservation than at any other place in our Province. Other localities are at Thorold, Limehouse (on the G. T. Railway), and Rockwood.

CATALOGUE OF NIAGARA FOSSILS.

GENERA AND SPECIES.	AUTHORITY AND REFERENCE.
Stromatopora concentrica	Goldfuss, 1820, Germ. Petref.
Caunopora walkeri	Spencer, 1882, Niagara Fossils.
" *mirabilis*	" "
Coenostoma constellatum	Hall, 1852, Pal. N. Y.
" *botryoideia*	Spencer, 1882, Niagara Fossils.
Dictyostoma reticulata	" "
Astylospongia praemosa	Goldfuss, 1880, Petref. Germ.
" *sp.*	
Aulocopina granti	Billings, 1875, Can. Nat.

HYDROZOA.

GRAPTOLIDÆA.

Phylograptus (?) *dubius*	Spencer, 1882, Niagara Fossils.
Dendrograptus ramosus	" "
" *simplex*	" "
" *dawsoni*	" "
" *frondosus*	" "
" *praegracilis*	" "
" *spinosus*	" "
Callograptus niagarensis	" "
" *granti*	" "
" (*Dendrograptus*) *multicaulis*.	" "
" *minutus*	" "
Dictyonema retiforme	Hall, 1852, Pal. N.Y.
" *gracilis*	" "
" *websteri*	Dawson, 1868. Acad. Geol.
" *tenellum*	Spencer, 1878, Can. Nat.
Calyptograptus cyathiformis	" " "
" *subretiformis*	" " "
" *micronematodes*	" 1882, Niagara Fossils.
" (?) *radiatus*	" " " "
Rhizograptus bulbosus	" 1878, Can. Nat.
Acanthograptus granti	" " "
" *pulcher*	" 1882, "
Inocaulis plumulosa	Hall, 1852, Pal. N. Y.
" *bella*	Hall & Whitfield, 1874, Pal. Ohio.
" *walkeri.*	Spencer, 1882, Niagara Fossils.
" *problematica*	" 1878, Can. Nat.
" *diffusa*	" 1882, Niagara Fossils.
" *ramulosa*	" " " "
" *cervicornis*	" " " "
" *phyocides*	" " " "
Thamnograptus bartonensis	" " " "
" (?) *multiformis*	" " " "
Ptilograptus foliaceus	" 1878, Can. Nat.
Cyclograptus rotadentatus	" 1882, Niagara Fossils.

ACTINOZOA.

TABULATA.

Favosites niagarensis .... Hall, 1852, Pal. N.Y., Vol II.
" *favosus* .... Goldfuss, 1826, Germ. Petref.
Astrocerium (Favosites) constrictum .. Hall, 1852, Pal. N.Y., Vol. II.
Syringolites huronensis .... Hinde, 1879, Geol. Mag.
Cladopora multipora .... Hall, 1852, Pal. N.Y., Vol. II.
Striatopora flexuosa .... " " " "
Halysites catenulatus .... Linnæus, 1767, Syst. Nat.
Syringopora verticillata (?) .... Goldfuss, 1826, Germ. Petref.

RUGOSA.

Cyathophyllum radiculum .... Rominger, 1876, Fos. Corals in Geol. Mich., Vol. III.
Omphyma stokesi .... Milne-Edwards, 1876, Fos. Corals in Geol. Mich., Vol. III.
Petraia Streptelasma calycula ...... Hall, 1852, Pal. N.Y., Vol. II.

ECHINODERMATA.

ASTEROIDEA.

Petaster bellulus .... Billings, 1865, Pal Foss., Vol I.

CRINOIDEA AND CYSTOIDEA.

Lyriocrinus dactylus .... Hall, 1852, Pal. N.Y., Vol. II.
Thysanocrinus liliiformis .... " 1852, " "
Eucalyptocrinus decorus .... Phillips, 1829, Murch. Sil. Syst.
Stephanocrinus angulatus .... Conrad, 1842, Jour. Acad. Nat. Sc.
Caryocrinus ornatus .... Say, 1825, " "

POLYZOA.

Ceramopora foliacea .... Hall, 1852, Pal. N.Y., Vol. II.
Clathropora (?) *gracilis* .... Spencer, 1882, Niagara Fossils.
Fenestella elegans .... Hall, 1852, Pal. N. Y., Vol. II.
Polypora (Fenestella ?) albionensis .. Spencer, 1880, Niagara Fossils.
Lichenalia concentrica .... Hall, 1852, Pal. N.Y., Vol. II.
Trematopora osteloata .... " " " "

BRACHIOPODA.

SPIRIFERA.

Spirifera crispa .... Hisinger, 1826, Act. Acad. Nat. Sc.
" *niagarensis* .... Conrad, 1842, Jour. " "
" *radiata* .... Hisinger, 1857, Petref. Suecica.
" *sulcata* .... Sowerby, 1825, Min. Concl.
" *plicatella*, var *radiata* ..... Hall, 1867, 20th Regent's Report.
Atrypa reticularis .... Linnæus, 1767, Syst. Nat.
Athyris (Meristina) nitida .... Hall, 1852, Pal. N.Y., Vol. II.

RHYNCONELLIDAE.

Rynconella neglecta .... Hall, 1852, Pal. N.Y., Vol. II.
" *obtusiplicata* .... " " " "
" " var .... " " " "
" *rugosa* .... " " " "
Pentamerus oblongus .... Vanuxem, 1842, Geol. 3 Dist. N.Y.
Sricklandinia canadensis .... Billings, 1859, Can. Nat.

STROPHOMENIDAE.

Strophomena profunda............. Hall, 1852, Pal. N.Y., Vol. II.
"   *rhomboidalis*.......... Wallenberg, 1821, Act. Soc. Sci. Upsala.
Strophodonta semifasciata.......... Hall, 1863, Trans, Alb. Inst.
Streptorhyncus tenuis.............. " 1858, " "
Leptena transversalis.............. Dalman, 1827, Kongl. Vet. Acad. Hanal.
Orthis elegantula................. Dalman, " " "
" *flabellelum* .... Hall, 1843.
" *porcata*................... McCoy, 1846, Sil. Foss. of Ireland.

CRANIADÆ.

Crania anna .... Spencer, 1882, Niagara Fossils.

DISCINIDAE.

Discina tenuilamellata............ Hall, 1852, Pal. N.Y., Vol. II
" *clara*..................... Spencer, 1882, Niagara Fossils.

LINGULIDEA.

Lingula oblonga.................. Conrad, 1839, Ann. Rep. N.Y.
" *lamellata*.................. Hall, 1852, Pal. N.Y., Vol. II.
" *ingens* .... Spencer, 1880, Niagara Fossils.

LAMELLIBRANCHIATA.

Avicula emacerata................ Conrad, 1842, Jour. Acad. Nat. So.
Pterinea brisa................... Hall, 1867, 20th Regent's Rep. N.Y.
Posodonomya rhomboidea.......... " 1852, Pal. N.Y., Vol. II.
Modiolopsis subalata............. " " " "
" sp................... " " " "

GASTEROPODA.

Platyostoma niagarensis.......... Hall, 1852, Pal. N.Y., Vol. II.
Lonoxema leda................... " 1867, 20th Regents Rep., N.Y.
Pleurotomaria clipeiformis .... Spencer, 1882, Niagara Fossils.

PTEROPODA.

Conularia niagarensis............. Hall, 1852, Pal. N.Y., Vol. II.
" *magnifica*............... Spencer, 1879, Can. Nat.
" *rugosa*............ . " 1882, Niagara Fossils.

CEPHALOPODA.

Orthoceras virgatum............. Sowerby, 1839, Murch. Sil. Syst.
" *annulatum* .... " 1818, Min. Concl.
" *simulator* .... Hall, 1876, 28th Reg. Rep. N.Y.
" *crebescens* (?).......... " 1867, 20th " "
" *bartonense*............. Spencer, 1882, Niagara Fossils.
Cyrtoceras reversum.............. " " "
Lituites niagarensis.............. " " "

ANNELIDA.

Cornulites flexuosus............... Hall, 1852, Pal. N.Y., Vol. II.

CRUSTACEA.

TRILOBITA.

Illaenus barriensis	Murch. 1839, Sil. Syst.
Encrinurus ornatus	Hall, 1852, (vid Cybele punctata).
Sphaerexochus romingeri	" 1867, 20th Reg. Rep. N.Y.
Calymene blumenbachii	Brongniart, 1822, Hist. Nat. Const. Foss.
Homalonotus delphinocephalus	Green, 1832.
Dalmanites limulurus	" "
Lichas boltoni	Bigsby, 1825, Jour. Acad. Nat. Sc.,
Acidaspis halli	Spencer, 1880, Niagara Fossils.

EURYPTERIDÆ.

Pterygotus Canadensis	Dawson, 1879, Can. Nat.

APPENDIX.

Besides the previous catalogues of fossils found in the different formations of the Niagara Group in Canada, Messrs. Nicholson and Hinde have obtained the following species:

CLINTON.

Scolithus verticalis	at Dundas.
Arenocolites sparsus	"
Planolites vulgarus	"
Stromatopora lundii	at Owen Sound.
Zaphrentis stokesi (?)	" "
Chætetes fletcheri	at Dundas.
Phænopora ensiformis	"
Ptilodictya crassa	"
" (?) *raripora*	"
" *punctata*	"
Leptocœlia planoconvexa	"
Orthis calligramma	"
Leptaena sericea	"
Tentaculites neglectus	"
Glyptocrinus plumosus	"

NIAGARA.

Stromatopora hindei	at Owen Sound.
Heliolites interstincta	" "
Favosites venusta	" "
" (?) *multipora*	" "
" *dubia*	" "
Cœnites (Limaria) laminata	" "
" *lunata*	" "
Alveolites fischeri	" "
" *niagarensis*	at Richmond.

Astræophyllum gracile..........	at Owen Sound.
Caunopora annulata.	" "
Syringopora retiformis..........	" "
Zaphrentis Roemeri......	" "
Cystiphyllum vesiculosum	at Thorold.
Petraia pygmæa..............	"
Diphyphyllum cæspitosum......	"
Clathopora fondosa............	"
" *intermedia*	"
Retepora asperato-striata.......	"
Trematopora osteolata	at Niagara River.
Fenestella tenuiceps	" "
Athyris intermedia....	" "
Strophomena subplana...... ...	at Thorold.
Orthis biforata	"

In the catalogue above-named we find 34 species of Clinton and 49 of Niagara fossils, collected by Messrs. Nicholson and Hinde, of which the above 39 species have not been obtained by me, or in so poorly preserved condition as to be rejected from my cabinet. In the catalogue the names of fossils are not usually placed in two formations, but only in that where they more generally occur.

In the catalogue of the fossils of the Medina, Clinton and Niagara, given here, there will be found 121 species of Niagara and 53 of Clinton and Medina, of which only a few species are repeated in the lists. The principal omissions in my cabinet are in the poorly preserved specimens of the Clinton, at Dundas, and in the species found at Thorold and Owen Sound. Neither of the lists includes 13 species of annelid jaws, recently described by G. J. Hinde, Esq.

APPENDIX A.

Catalogue of Fossils of the Hudson River Formation, found in the Old Beaches at the western end of Lake Ontario.

The study of the occurrence of these fossils belongs, strictly speaking, to the Drift, which will be described in a subsequent paper. From the Palæontological point of view, they are more interesting in connection with this portion of the study of the Geology of the Region about the Western End of Lake Ontario than in that of the Surface Geology.

The following is a list of the fossils which I have obtained in considerable quantities from the fossiliferous pebbles of both the ancient and modern beaches in the region of Hamilton:

Stenopora fibrosa, Goldfuss.
Columnaria alveolata, Billings.
Athyris headi, Billings.
Strophomena alternata, Conrad.
Strophomena deltoidea, Conrad.
Leptæna sericea, Sowerby.
Orthis testudinaria, Dalman.
Orthis occidentalis, Hall.
Orthis lynx, Eichwald.
Obolella crassa, Hall.
Modiolopsis modiolaris, Conrad.
Modiolopsis ——— (several undermined species).
Cyrtodonta harrietta, Billings.
Orthonota ———
Ctenodonta ———
Lyrodesma poststriata, Emmons.
Ambonychia radiata, Hall.
Avicula demissa, Conrad.
Murchisonia gracilis, Hall.
Cyrtolites ornatus, Conrad.
Orthoceras lamellosum, Hall
Ormoceras crebiseptum, Hall.
Leperditia canadensis, Jones.

APPENDIX B.

Since writing the Report on the Palæozoic Geology of the Region about the Western End of Lake Ontario, I have observed that Dr. Hunt, in his Report on the Canadian Petroleum Regions of Canada (1863–66), gives the log of a well sunk on the eleventh lot of the seventh range of Barton, which is as follows:

Limestones with a little shale........	250	feet
White sandstone........	5	"
Red shales with bluish bands.........	595	"
Bluish and grayish shale.............	23	"
	873	"

The location of this well is about two and a half miles southward of the brow of the "Mountain" at Hamilton. The upper 250 feet include both the Niagara and Clinton formations, which measurement is almost precisely the same as the thickness of these strata ascertained by measurement at Dundas. Consequently, we may consider the summit beds in both places as nearly identical, whilst the beds at Carpenter's Limekilns, not much more than a mile distant from the Barton well, are

geologically and geographically higher than at its mouth, but geographically lower than the inferior beds at Dundas, on account of the dip of the strata.

The five feet of sandstone constitute the prevailing "Gray Band" of the Medina formation.

The thickness of the Medina shales appears to be 595 feet. I have placed the thickness of the Medina shales at 535 feet; this being derived from the record of the well at Dundas, where they are underlaid by "limestones and grits," whilst in the Barton well the *red shales* are underlaid by "bluish and grayish shales," which probably belong to the Hudson River group.

It must be remarked that the Dundas well is not far beyond the turn in the bend of the Niagara escarpment, which I have designated by the name of ancient Cape Dundas. In the previous Report attention has been frequently called to the fact that all the shaly deposits decrease, and those which are calcareous increase the moment that we pass around the provisionally called Cape Dundas. In proceeding northward the Medina shales thin out and are last seen at Cabot's Head, and, according to Dr. Bell, are entirely absent from the series in the Manitoulin Island. Therefore this difference of about 60 feet is one of thickness and not of error. It was also noticed that in proceeding south-westward towards Ohio, that the Medina shales almost entirely disappear.

Had I known of the existence of the well in Barton at the time that I took the levels over the adjacent localities, it would havo given an additional point for correcting the estimate of the dip. The altitude of the place, about a quarter of a milo northeast of the well, is 435 feet above Lake Ontario, while at a quarter of a mile to the eastward, it is 424 feet, on a surface of rocks. Calculating from these data, the dip would be between 22 and 27 feet in a mile, but as the well is between these two points, we can retain our old estimate of 25.4 feet in a mile, having a direction of 20 degrees west of south.

THE GEOLOGY OF ST. IGNACE ISLAND, LAKE SUPERIOR.

By Charles Robb,

Mining Geologist, Montreal.

(*Read before the Natural History Society, Feb.* 27, 1882.)

The region bordering on the North or Canadian Shore of Lake Superior is daily rising into importance both in a scientific and practical and, I may add, in an æsthetic point of view; affording, as it does, ample scope for the investigations of the geologist and naturalist, the explorations and operations of the miner, and the delectation of the tourist and artist in search of health and of the picturesque in nature. Not very many years ago this region was regarded as remote and almost inaccessible; but the modern facilities for travel, and the ever active and expansive growth of commerce and civilization, are rapidly bringing it within the reach of all; and a new interest has very recently been added to it, by the fact that the Canada Pacific Railway will, it is hoped, within a few years be constructed along, or near its shores. Already the South Shore of this great lake, for a considerable part of its extent, is occupied by a numerous, thriving and rapidly increasing population. It is to be feared that our side, in consequence of numerous and insurmountable natural obstacles, can never compete with the American in that respect; but, notwithstanding the extremely rugged and sterile nature of the country, enough remains in its mines and fisheries, and in its grand and beautiful natural features, to make it a place of great interest and importance.

During the course of last summer I had occasion to visit professionally and spend about three months on the Island of St. Ignace, one of the largest of the out-lying islands on the North Shore, where I was engaged with a small party in mining explorations, or rather in searching for mineral veins which might serve as a basis for mining operations, on a ten square mile location, lying at the south-eastern extremity of the island, and belonging to the Quebec and Lake Superior Mining Association of this

---

The paper was illustrated by maps and numerous specimens.

city. Partly to aid in the object of my visit and partly with the idea that it might be interesting in a scientific point of view, I took occasion to make a somewhat minute and careful geological and topographical examination of the coasts of the location, which are, in fact, almost the only parts available or accessible for such a purpose; and I have thought the results might be of sufficient interest to lay before this Society, having been invited and encouraged by our worthy president, Dr. Dawson, to do so. So far as I am aware, no minute or detailed examination has hitherto been made of this island, or indeed of any part of the North Shore of Lake Superior. Many important points in regard to its structure are involved in considerable obscurity from the want of such details; and I hoped that my humble efforts might serve as a contribution, however slight, to such knowledge, and as an addition to the general stock of information on the subject.

The Island of St. Ignace is, as already stated, one of the three largest on Lake Superior; the largest, Isle Royale, is on the American side, or at least claimed by and conceded to the State of Michigan, and the other two, Michipicoten and St. Ignace, are very nearly the same size, or about 16 miles long by 8 miles in width, or 128 square miles area. The Island of St. Ignace fronts the mouth of the Nipigon River, being separated therefrom by a wide bay or channel; and is distant about 230 miles from Sault St. Marie, at the eastern end of the Lake, which is here nearly 100 miles wide. In approaching St. Ignace from the east, one is at once struck, at the distant view, with the change from the somewhat tame and monotonous contour of the Laurentian and Huronian hills, to the extremely rugged and picturesque outlines of the Volcanic Mountains; and a closer inspection suffices to show these features in all their wild grandeur. Being still, for the most part, unexplored and very rarely visited, and being entirely devoid of human occupants, it is almost in a wilderness condition, and is exceedingly rough, rocky and mountainous; and being, moreover, densely covered with timber, underbrush, matted roots, moss, etc., it is very difficult to penetrate into the interior. The coast is also much exposed to the storms from the lake, and is generally fringed with steep rocky cliffs, rising abruptly from the deep waters of the lake, but varied frequently by bays and beaches; and the numerous small islands and projecting promontories existing along its southern shores afford occasionally deep and sheltered harbors, although, by reason of

the sunken rocks, much caution and vigilance have to be exercised in approaching them by boats. The camping ground which was selected by me, towards the south-eastern end of the location, is a good example of one of these harbors, and is in fact the only safe one on the place.

The geological structure of this part of the island (and I believe it is nearly the same throughout) is extremely simple, and will be readily understood. A deep bay running north and south, (St. Ignace Bay) and forming the eastern boundary of the location, cuts the rocks transversely and affords an excellent natural section. The rocks belong to what is designated by Sir William Logan the upper group of the Upper Copper-bearing Rocks of Lake Superior, corresponding to the Keeweenian Formation of Dr. Hunt; and are regarded by Sir William as the equivalents of the metalliferous rocks of the Eastern Townships of Lower Canada, which he has denominated the Quebec Group of the Lower Silurian system. They form part of the same series in which the great native copper mines of the South Shore of the Lake have been opened up; and there seems no reason to doubt that they are of volcanic origin. The rocks of the location under notice are probably at the extreme upper part of the formation.

The prevailing rock of the country is a granular amygdaloid trap or melaphyre,* consisting of a small-grained mixture of dark brown feldspar, with angular grains of dark-green chloritic mineral, probably delessite. It varies frequently in its structure, and the upper part, to which this notice refers, contains amygdules, or small spherical masses or nodules of calcspar and delessite. To this it may be added that quartz, chiefly in the form of agate, jaspar and amethyst, is of frequent occurrence in the amygdules, as also epidote, prehnite and laumontite, with various zeolite minerals. It is to this rock also that the metals would seem chiefly to belong; such as copper and silver, both native and sulphuretted, also magnetic and specular iron; although workable deposits of these metals are only to be looked for in veins traversing the rocks, or at the planes of junction between them and another description of rock; and it is to be remarked that the vein-stones are always composed of the same minerals as are found in the amygdules.

* According to the description given by Mr. Thomas Macfarlane, of corresponding rocks occurring at Mamainse. See this Joornal, Vol. VII

The amygdaloid trap, although not of sedimentary origin, in the ordinary acceptation of the term, is regularly bedded, having a very distinct dip to the south, at an angle of about 13° ; and is overlaid, at numerous points, by a compact, very hard and heavy, finely-crystalline trap or greenstone, or it may be diabase or basalt. Which of these is the more correct term, I confess I am not sufficient of a mineralogist to determine, nor could it be accurately determined without an analysis. It is probably composed of the same mineral ingredients as the body of the amygdaloid trap, but with a very different texture and appearance; and is entirely devoid of the characteristic amygdules or small rounded masses of foreign minerals which occur so copiously in the other rock. This overlying rock is, I believe, that which, by the South Shore miners, is always designated as *Greenstone,* and it is there well understood that it is generally at or near its junction with the underlying amygdaloid trap that the productive metalliferous veins or deposits are to be found. In the present case it overlies the amygdaloid in numerous isolated knobs, patches and ribs, distributed along the eastern shore of the location, and some of the small outlying islands, standing out in bold precipitous bluffs and precipices, sometimes about 100 feet high, plunging into the deep waters of the lake; the intervening spaces being excavated by the waves into deep bays terminated by gravel beaches.

In some instances the masses of crystalline trap or greenstone are abruptly terminated downwards, at or very near the level of the lake; and their planes of junction with the amygdaloid are distinctly visible at that point, maintaining the regular dip of the amygdaloid beds, although the greenstone itself shows no tendency to a bedded structure. In other instances there appears to be a sort of passage between the two—I mean only in so far as their distinctive mineral characters are concerned. In two places the greenstone assumes a basaltic columnar structure both vertical and horizontal; and the surfaces of the rocks are there sometimes found to be coated with pitchstone, or perhaps the rare mineral tachylyte, as suggested to me by Dr. Harrington.

By reason of the hardness and extremely refractory nature of the crystalline trap, the masses exposed on the shores of St. Ignace Bay stand up conspicuously above the general level of the amygdaloid, with steep mural faces to the north; forming ridges running inland in a due westerly direction, conformably

with the strike of the amygdaloid beds. I had no opportunity of observing, in most instances, how far they extend inland; but in two cases they are distinctly terminated at a very short distance from the shore—the serrated and indented aspect of which is doubtless due to the resisting qualities of the harder rock acting like the enamel on a tooth. With perhaps two exceptions which I shall proceed to notice, the crystalline trap masses cannot be regarded as intrusive, as supposed by Sir William Logan, at least not at this place. The impression conveyed to my mind by the whole phenomenon—if I may be allowed to theorize—was that the materials of the amygdaloid had been first ejected in the form of volcanic mud or ashes, and thereafter overflowed by a fluid current of molten matter of nearly the same chemical constitution, but very different mechanical properties, filling up cracks, fissures and depressions in the original surface, and thereafter denuded, leaving only such portions as we now find in the form I have attempted to describe.

One very notable exception (or perhaps two) to this arrangement has to be remarked. I refer to the existence of a great dyke of the same hard crystalline trap, undoubtedly penetrating the amygdaloid in a nearly vertical direction to an indefinite depth, and also extending indefinitely inland to the west, parallel to the strike, in a perfectly straight line, and preserving a uniform thickness of about sixty feet. It is of a transversely horizontal columnar or rather sub-columnar structure, the columns lying truly at right angles to the direction of the dyke, and dipping south at an angle of 7°, or exactly at right angles to its downward direction, which deviates to this extent from the perpendicular. The dyke juts out boldly into the deep waters of St. Ignace Bay about the centre of the location; and, no doubt, together with the hardness of the adjacent masses of crystalline trap, has been the cause of the existence of the great projecting cape of amygdaloid to the north, by protecting it from the wasting action of the waves. It is flanked on either side by veins of a remarkably promising character for silver and copper; the vein-stone, which is entirely different from the inclosing rocks, although containing fragments of them, being composed of quartz, calcareous spar, baryta, laumontite, prehnite and much chloritic matter, together with garnets, native silver in very fine loose particles, and vitreous copper ore. It was to these veins, after discovering them, that I chiefly directed my attention in

connection with the main object of my visit to the island, but the details of these operations I do not propose to describe on the present occasion.

This dyke may have been filled, like the other crystalline trap masses, from above; but I am more inclined to the opinion that it was injected or intruded from below, and may, in fact, have been the vent from which the others were supplied; for which latter opinion I have some special reasons which I shall submit further on. There is another somewhat similar, but evidently much less important dyke, occurring near our camping ground, and running in an entirely different direction, but it is unnecessary now to do more than merely mention its existence.

Towards the southern end of the location, and also in one of the small outlying islands, red sandstones, breccias and conglomerates appear to overly the amygdaloid in small detached patches; but I have no doubt that these mark only the basset edge or northern extremity of a great mass or stratum of the same character, forming the bed of the lake and extending indefinitely southwards under it. Associated with these at the locality under notice occur enormous masses of porphyritic trap, to which, as being a rather remarkable rock both for its scientific or geognosic interest and for its beautiful appearance, especially when polished, I desire to direct your special attention. Although not apparently a bedded or even a jointed rock, it occurs interlaminated with the red sandstones, or at least distinctly overlying them in regular planes of junction, conforming with the dip of the sandstone, which is 30° to 40° to the south. It is also seen at one place conspicuously to overlie the amygdaloid (which here dips at the same higher angle) conformably at or near the water level, at the base of a high beetling cliff of the porphyry, the significance of which facts I shall presently proceed to explain. The same rock occupies uninterruptedly, for about two miles, almost the entire southern limits of the location, forming a succession of bold headlands fronting on Lake Superior; and is succeeded in going west by the underlying red breccias.

From these facts, I think it will undoubtedly be obvious that the porphyry belongs to, and is newer than the sandstones and amygdaloids lying to the north of it.

These rocks I take to be the same as those described by Dr. T. Sterry Hunt, in his able "Report on the Trap Dykes and Azoic Rocks of South-Eastern Pennyslvania, 1878," which are

by him stated to be highly characteristic of the Huronian series, and his description seems to me to be so exactly applicable to the present case, that I shall take the liberty of quoting it, together with a summary of his inferences and conclusions; although my own deductions may be somewhat at variance with his as to their relations with the surrounding rocks.

In the above-mentioned Report, page 192, Dr. Hunt says:

"Felsites and felsite-porphyries are well-known in eastern Massachusetts, and may be traced from Macchias and Eastport in Maine along the southern coast of New Brunswick to the head of the Bay of Fundy, with great uniformity of type, although in every place subject to considerable variations, from a compact jasper-like rock to more or less coarsely granular varieties, all of which are often porphyritic from feldspar crystals, and sometimes include grains and crystals of quartz. The colors of these rocks are generally some shade of red varying from flesh-red to purple; pale-yellow, gray, greenish and even black varieties are, however, occasionally met with. These rocks are throughout this region distinctly stratified, and are closely associated with dioritic, chloritic and epidotic strata. They apparently belong, like these, to the great Huronian series."

Again, speaking of the same rocks, at page 193, he says:

"These were compared with the similar strata along the Atlantic coast, from Rhode Island to New Brunswick, interstratified with rocks having the characters of the Huronian series, to which great division I have provisionally referred these bedded petro-silex rocks, with the suggestion that they probably occupy a position near the base of the series. These rocks were declared to be identical in lithological characters with the *Halleflinta*, or stratified flint-rock of the Swedish geologists, which is by them assigned to a horizon just above the more ancient or Primitive Gneiss; and are important, as including in Norway, the most considerable deposits of crystalline iron ores. These same rocks are met with in various localities in the Huronian series, on the Upper Lakes, and are well displayed, as observed by the writer, in a small island lying a little to the south of St. Ignace Island, and for some distance along the shore to the adjacent mainland to the southwest. Epidote, chlorite and a steatitic mineral are occasionally met with in these petro-silex rocks, and magnetic and specular oxyds of iron occur disseminated, in interstratified masses and in veins intersecting the strata."

Again, at pages 229 and 232, he says:

"The reader is now prepared to understand the significance of the question raised by the writer in 1871, as to the existence of the felsite or petro-silex porphyries in place in the Lake Superior region; since these rocks, which had then been found by him to belong to the

Huronian series, occur in pebbles in the conglomerates of the Upper Copper-Bearing series. Besides the locality already mentioned," (the Albany and Boston Mines) "the great cupriferous bed of the Calumet and Hecla Mine is a remarkable example of a rock made up almost wholly of the ruins of these peculiar petro-silexes. In 1872, as already described, he found these rocks *in situ* on the north shore of Lake Superior."

Referring to the small island, lying a little to the south of St. Ignace, he further states at page 232:

"These rocks, from the lithological descriptions given, including the microscopic characters, and the results of chemical analysis, are evidently identical with the orthofelsites or petro-silex poryphyries previously described by the writer as characteristic of the Huronian series along the Atlantic coast, etc. They are the same with those discovered by him on the north shore of Lake Superior, and which enter so largely into the cupriferous conglomerates of the Keeweenian series, on the south shore of the lake."

My inference from Dr. Hunt's remarks is, that he undoubtedly regarded these porphyries, even where they occur "on a small island lying a little to the south of St. Ignace," as belonging to the Huronian formation, and even to the base of that series. The island referred to obviously occupies the same geological position and may even be in the same area as that described by me, but I think we have positive and conclusive proof in the facts which I have adduced, that the latter are associated with and overlie the great Upper Copper-Bearing or Keeweenian group, which, according to Dr. Hunt's determinations, overlies his Taconian and Montalban terrains. And if this peculiar rock can be shown *not* to be exclusively characteristic of the Huronian, we need not, perhaps, go so far down in the geological series as to that horizon to seek for the origin of the pebbles in the Calumet and Hecla conglomerates; and, if my deductions are correct, they may similarly affect many determinations cited on the highest authority. Even if we had no direct evidence of the superposition of the porphyries on the amygdaloids and conglomerates, the fact that the latter, at this place, contain *no pebbles* of the porphyry is, in my view, a strong corroborative proof of the more recent age of the porphyry. If these rocks are Huronian, there must be an interval, according to Dr. Hunt's own figures, of at least 50,000 or 60,000 feet of strata between them and the rocks with which they are so intimately associated. This could hardly be accounted for by a fault, even if the relative conditions of the rocks could lend any countenance to such

a theory, which they do not. May not this, I would respectfully ask, be an instance of the danger of yielding undue prominence to lithological characteristics in determining the comparative age of rocks, in the absence of stratigraphical or palæontological evidence?

Some of the high lands in the interior of the location are composed of a different and probably much more recent description of eruptive or volcanic rocks than any of those described. Thus at a point about two miles from the southern and one mile from the eastern boundary (or lake shore), a mountain of trachyte or phonolite rises to an altitude of from 800 to 1000 feet, in which there occurs a remarkable rift or cavity, evidently connected with the dykes or veins which traverse the subjacent rocks, thus proving that the origin of these latter is of a more recent date than that of all the rocks through which they have penetrated. I should add here, *en parenthèse*, that besides the great dyke and associated mineral veins which I have noticed as occurring here, there are distinct traces of the former existence of a great parallel vein, or set of veins immediately to the south, which, by breaking up the continuity of the rocks and thereby weakening them, have given rise to the remarkable deep bay lying immediately to the south.

I have referred to a line of weakness and probable rupturing of the rocks eastwards from the great rift, fissure or crater in the trachyte mountain, giving origin to the deep peculiar shaped bay, which I have called Mines Bay. If we trace the same line still further eastwards to the other side of the bay, we find a deep narrow channel between the south end of Harrison's Location and Bead's Island to the Chenal Ecarté, running up from Lake Superior to Nipigon Bay. This narrow channel probably owes its origin to the same cause, namely, the weakness of the rocks forming its bed; and we may also observe that the same metalliferous veins which have been discovered and partially explored on Harrison's Location, correspond in position and direction with those which I have recently discovered, without being aware of this relation, on the main land of St. Ignace.

The intervening great bay has evidently been scooped out by a glacier, as the glacial striae are exceedingly well marked and conspicuous, running exactly parallel with the direction of the axis of the bay; and they are more strikingly displayed on the hard porphyry rocks than on the softer amygdaloids; this being, no doubt, due to the more resisting character of the former.

Notice of a Memoir on Glaciers and Icebergs in Relation to Climate, by Dr. A. J. Von Wœickoff. (In the Proceedings of the Geological Society of Berlin, 1881.) With remarks by Principal Dawson, F.R.S.

This memoir presents a very clear statement of the physical causes and conditions of the accumulation and distribution of snow and ice in different parts of the world, in illustration of the possibility of the existence of continental glaciation in the Pleistocene age. The following is a free translation of the author's summary of his conclusions, which though sufficiently trite as matters of physical geography, are deserving of repetition at a time when the principles of that science are treated with so great contempt by certain schools of glacialists.

1. The presence of water tends to moderate the extremes of temperature both in *place* and in *time*.

2. It does this, both by virtue of its great capacity for heat, and by its cooling and heating powers when passing from the solid into the liquid and gaseous states, and the reverse.

3. These effects extend widely in place and time. For example, near the south pole, the higher strata of air are warmed by the abundant congelation of vapour into snow, and the snow having fallen and having been changed into the ice of glaciers and icebergs, is in that condition carried far to the north, and hundreds of years after it has fallen as snow, is active in cooling the ocean and the air as far north as the latitude of 40°.

4. The general effect of the changes of condition of water, along with the resulting formation of clouds and mists, is to raise the temperature of winter and to depress that of summer.

5. The currents of the ocean have an especially great influence in the mitigation of the extremes of temperature, the direct effect of which is much greater than that of the winds.

6. The winds appear to act mainly in diffusing the temperature of the ocean currents.

7. Though the winds may be in the first instance the motive power of the main oceanic currents, yet the effects of the distribution of land and of the form of the sea-bottom become paramount in influencing these when once set in motion.

8. At the present time, the distribution of the trade-winds and monsoons is such as to divert a large quantity of warm equatorial water into the northern hemisphere, producing an excess of warmth above that of the S. Hemisphere between latitudes 40° and 59° N.

9. This effect is intensified by the narrowing of the seas to the north, and is of course especially felt on the western sides of the continents.

10. Not only does the Southern Hemisphere thus lose a large share of its warm water, but the effect of the remainder is dissipated by being spread over a vast expanse of sea.

11. This great expanse of ocean in the Southern Hemisphere is favourable to the deposit of snow and formation of glaciers, by furnishing a great evaporating surface, and at the same time a low general temperature facilitating precipitation. This applies to the Antarctic continent, and also permits the formation of glaciers far to the north in New Zealand and in South America.

12. On the other hand the present condition of the Northern Hemisphere is unfavourable to glaciers, because the sea is so warm that deposition near the coasts is rather as rain than snow up to pretty high latitudes, while the continents are so wide that there is little precipitation in their interior.

13. Thus there are no glaciers in Eastern Siberia, even in the mountains, where the mean temperature is only 15° to 16° C., and Central Asia generally is unfavourable to glaciation on account of its dryness, while Eastern Asia is acted on by the monsoons. If, therefore, the extent of land in Asia has not materially changed since the Pliocene period, there could not have been great glaciers there since that period. Even the submergence of the great plain of China could not materially affect this result, though it might cause glaciers in the mountains of Japan.

14. To explain the great Post-pliocene glaciers, of which traces are found in Western Europe, it is necessary to suppose that the temperature was lower, either on account of submergence of the low lands or of diversion of warm currents, or both causes may have operated. A submergence connecting the White and Baltic Seas would greatly promote the production of snow and ice. But this could not affect the interior of Russia or of Asia, so long as their plains remained above water.

15. The submergence of the plains must be a necessary condition of the general glaciation of the higher lands.

16. Astronomical changes do not affect this result. With a great eccentricity of the orbit and the winter in aphelion the colder winters and hotter summers would produce more powerful monsoons, while on the opposite condition the interior of the continents would have warmer winters and cooler summers and weaker monsoons. In either case the conditions for continental glaciers would not be improved.

17. These considerations show that general coverings of ice stretching from the Pole to perhaps 45° are impossible. Under conditions of submergence of the plains the sea must keep open, in order to afford material for snow on the remaining high lands, and with large continental plains the climate will be too dry for glaciers. Thus there must always be seas free from ice, or continental plains free of ice, and under most supposable conditions there must be both.

Applying these very simple geographical truths to the North American continent, it is easy to perceive that no amount of refrigeration could produce a Continental glacier, because there could not be sufficient evaporation and precipitation to afford the necessary snow in the interior. The case of Greenland is often referred to, but this is the case of a high mass of cold land with sea mostly open on both sides of it, giving, therefore, the conditions most favourable to precipitation of snow. If Greenland were less elevated, or if there were dry plains around it, the case would be quite different; as Nares has well shown in the case of Grinnel land, which in the immediate vicinity of Greenland presents very different conditions as to glaciation and climate

If the plains were submerged and the Arctic currents allowed free access to the interior of the continent of America, it is conceivable that the mountainous regions remaining out of water should be covered with snow and ice, and there is the best evidence that this actually occurred in the glacial period; but with the plains out of water, there could never have been a sufficiency of snow to cause any general glaciation of the interior. We see evidence of this at the present day in the fact that in unusually cold winters the great precipitation of snow takes place south of Canada, leaving the north comparatively bare, while as the temperature becomes milder the area of snow deposit moves further to the north.

The writer of this note has always maintained these conclusions on general geographical grounds, as well as on the evidence

afforded by the Pleistocene deposits of Canada, and he continues to regard the supposed evidence of a terminal moraine of the great Continental glacier as nothing but the southern limit of the ice-drift of a period of submergence. In such a period the southern margin of an ice-laden sea where its floe-ice and bergs grounded, or where its ice was rapidly melted by warmer water, and where consequently its burden of boulders and other debris was deposited, would necessarily present the aspect of a moraine, which by the long continuance of such conditions might assume gigantic dimensions.

In the recent remarkable work on glaciers by Messrs. Shaler and Davis, it is apparently maintained that in North America a continental glacier extended in temperate latitudes from sea to sea, and this glacier must, in many places at least, have exceeded a mile in thickness. Independently of the physical difficulties attending the movement of such a mass without any adequate slope, difficulties with which the authors endeavour to deal, though not very satisfactorily, it is obvious, from the considerations above stated, that the amount of snow necessary to the production of such a glacier could not possibly be obtained. With a depression such as we know to have existed, admitting the Arctic currents along the St. Lawrence Valley, through gaps in the Laurentian watershed, and down the great plains between the Laurentian areas and the Rocky Mountains, we can easily understand the covering of the hills of eastern Canada and New England with ice and snow, and a similar covering of the mountains of the west coast. The sea also in this case might be ice-laden and boulder-bearing as far south as 40°, while there might still be low islands far to the north, on which vegetation and animals continued to exist. We should thus have the conditions necessary to explain all the anomalies of the glacial deposits. Even the glaciation of high mountains south of the St. Lawrence Valley would then become explicable by the grounding of floe-ice on the tops of these mountains when reefs in the sea. The so-called moraine, traceable from the great Missouri coteau in the west, to the coasts of New Jersey, would thus become the mark of the southern limit of the subsidence, or of the line along which the cold currents bearing ice were abruptly cut off by warm surface waters.

Whatever difficulties may attend such a supposition, they are small compared with those attendant on the belief of a continental

REPORT ON THE PETER REDPATH MUSEUM OF McGILL UNIVERSITY.

Prepared by PRINCIPAL DAWSON *for the first meeting of the Museum Committee, March* 11*th*, 1882.

[In the terms of the gift of the Peter Redpath Museum to the University, it is provided that the immediate management of the Museum shall be entrusted to a "Standing Committee of the Corporation, to be called the Museum Committee, to consist of the Principal as Chairman, and three other members of the Corporation, with whom shall be associated the Logan Professor of Geology and the Professors of Mineralogy, Zoology and Botany, and of other departments of Natural History in the Faculties of Arts or Applied Science of McGill College, should there be such Professors. The Committee shall have power to appoint any of its members Honorary Curator or Curators of the Collections or of any part thereof, and to arrange the times at which different Professors and their classes may teach or study in the Museum."

A Museum Committee was accordingly appointed by the Corporation of the University, at its meeting in January, 1882, and consists of the following members: The Principal (*ex officio*), Peter Redpath, Esq., Hon. Mr. Justice McKay, Dr. G. W. Campbell, Dr. B. J. Harrington (*ex officio*). The following report was presented by the Principal to the first meeting, with the object of placing on record the steps taken by him up to that time in his capacity of Curator of the Museum, under the regulations of the University.]

The noble Museum, erected for the University by the munificence of Mr. Redpath, has now so far advanced toward completion, that it will probably be ready for the reception of specimens in May next, and it is extremely desirable that the collections to be contained in it shall be in as perfect a condition as possible at the time of the formal opening, which is intended to take place on the 24th of August, on occasion of the meeting of the American Association in Montreal. In view of these dates, it

has been necessary to devote special time and attention for some months past to the arrangement and preparation of the specimens in the present Museum, and in the collections recently added to it by donation or purchase. The present report is intended to record the steps which have been taken or are in progress toward this end.

ARRANGEMENT, LABELLING, ETC.

In June. 1881, Mr. Thomas Curry was engaged to mount, label and otherwise prepare specimens, and has been steadily engaged in this work since that time. The expense of mounting materials has been charged to the Museum fund. Mr. Curry's salary has been paid by the liberality of a lady of this city, who has also placed at the credit of the Museum a sum sufficient to secure his valuable services for some time longer.

Mr. P. Kuetzing has been employed, for a part of his time, to remount and renovate the specimens of vertebrate animals and to prepare some new specimens which have been purchased. He has up to this time been occupied more especially with the collection presented by the heirs of the late Dr. McCulloch. It is hoped that by the end of May he will have gone over the whole of the material of this kind possessed by the University and will have brought it up to a creditable condition.

Dr. Harrington and myself have been giving as much attention as possible to the proper naming of the minerals, rocks and fossils, and to their orderly and systematic arrangement, preparatory to removal to the cases of the new building.

DONATIONS AND EXCHANGES.

Under this head reference will be made to the principal contributions recently made to the collections, and more especially to those particularly intended for the Peter Redpath Museum.

Principal Dawson's collections in the Geology and Natural History of Canada are in process of being arranged and mounted, along with the other specimens. The conditions of this donation, approved by the Board of Governors, are, that the specimens, while not kept separate from the general arrangement, will be labelled with the name of the donor, and that he and Dr. G. M. Dawson shall have access to them for purposes of study, and with reference to their safe keeping. The total number of speci-

mens in the collection cannot as yet be definitely stated, but is estimated at from six thousand to ten thousand specimens, besides much material available for exchanges. It may be stated here that for the past twenty years the duplicates of this collection, and more especially of the new species described by Dr. Dawson, have been used in exchanges for the benefit of the Museum, and that a large part of the specimens now in the cases and drawers have been obtained in this way.

The following are among the more important of the other donations recently received :

From the Director of the Geological Survey, about 500 specimens of fossils and minerals, and twenty-three casts of large and unique fossils.

From Dr. T. Sterry Hunt a collection of thirty-two species of Canadian fishes, prepared by Mr. W. Couper, of Montreal.

From the heirs of the late Dr. McCulloch, the whole of his valuable collections of birds and mammals, including 170 species—a collection having an historical value, in connection with the labours of Dr. McCulloch and the revision of the nomenclature of the specimens by the late Prince Charles Lucien Bonaparte.

From George Barnston, Esq., a valuable collection of fossil fishes from the Devonian of Scotland.

From Lieutenant-Colonel Grant, of Hamilton, Ontario, a large number of fossils from the Niagara formation, some of them of great rarity and interest.

From the American Census Commissioners, a valuable collection of American woods.

From the New York Museum of Natural History, through Professor Whitfield, a collection of 700 specimens of fossils, named by Professor James Hall. In exchange for this a complete collection of the Devonian plants of Canada, from the collections of the Principal and of Professor Hartt, has been given to the New York Museum.

From Peter Redpath, Esq., the skull of a Greenland whale, with the baleen perfectly preserved.

From Dr. G. M. Dawson, specimens of mammals from the N. W. Territories.

From Dr. Spencer, of Kings' College, Windsor, specimens of fossils from the Niagara and Corniferous formations.

In addition to these, valuable contributions have been received from the Smithsonian Institution, Prof. Marsh of Yale College,

Charles Gibb, Esq., of Abbottsford, Professor Hilgard of Washington, Captain J. A. Vibert, E. De Cew, Esq., of Cayuga, Mr. Damon of Weymouth, Mr. Chatfeld of Syracuse, Mr. F. Starr of Auburn, A. J. Hill, Esq., C.E., Charles Robb, Esq., J. G. Miller, Esq., Mr. H. M. Ami, J. F. Torrance, Esq., B.A., T. Bland, Esq., of New York, J. F. Whiteaves, Esq., Professor Cope of Philadelphia, W. S. Davidson, Esq., of Edinburgh, and others. Details of these gifts have from time to time appeared in the public prints and in the College Calendar.

PURCHASES AND EXPENDITURES.

In order to complete the collections in a manner worthy of the new building, and to make up for the loss sustained by the removal of the collections of the Geological Survey from Montreal, it has been necessary to make some purchases and to engage the services of collectors to supply certain deficiencies.

The collection of Devonian plants in the possession of the late Professor Hartt of Cornell University, at the time of his death, was purchased for $250. It has afforded a few new species which have been described, several good museum specimens and materials for exchanges.

Casts of fossils, models of animals and specimens, have been purchased from the collections of Messrs. Ward and Howell of Rochester, for $451.

A few valuable and rare birds, not in our other collections, have been purchased of Mr. Passmore of this city for $55.

The sum of $25 was expended in procuring a collection of the interesting silicified fossils of Paquette's Rapids, on the Ottawa.

A collection of fossil fishes from the Cretaceous of Mt. Lebanon, has been purchased for $34.

From E. De Cew, Esq., of Cayuga, an important collection of Corniferous corals, including some specimens of unusual size and perfection, was purchased for $50. Mr. De Cew also presented some other fossils of interest from his own collections.

The valuable services of James Richardson, Esq., late of the Geological Survey of the Dominion, were secured during the past summer, with the view of procuring specimens of some of the more rare and characteristic fossils of the Cambrian and Lower Silurian rocks. Mr. Richardson has engaged in this work without remuneration, and he was enabled to obtain a large number of valuable specimens at a very moderate expense.

One of Professor Ward's excellent copies of the great skeleton of the *Megatherium* in the British Museum, and a number of other large casts have been contracted for and are to be delivered in the course of next month. The net cost of these casts is $568, and with the freight and fitting up it will amount to about $800.

A number of smaller collections and single specimens have been purchased from time to time as opportunity offered. The expense of some of the above purchases has been borne by the Museum fund. The sums paid for the others have been advanced by the Principal.

I have much pleasure in adding that several of the larger and more important specimens and collections referred to under this head are intended to form a memorial in the Museum to the late Sir W. E. Logan, and when the mounting of them has been completed will be paid for by a donation from his heirs.

Certain expenditures have been required on the grounds in the vicinity of the Museum. A portion of these have been defrayed by the University; but the greater part by private contributions, among which may be mentioned the donation of new and rare shrubs and trees by Charles Gibb, Esq. The arrangement of the grounds will be continued in the spring, but without any considerable expenditure.

CONCLUDING REMARKS.

The work of arranging, re-labelling and mounting specimens is so far advanced that we shall be able to occupy the Museum so soon as its cases can be fitted up.

The cases have been contracted for by Mr. Roberts, and will, it is believed, be as nearly as possible perfect in their arrangements for the protection and display of the specimens. Mr. Redpath has added to his other liberal gifts the provision of these cases at an expense of $10,000.

The plan of the arrangement of the collections has been fully decided beforehand, with reference to the dimensions of the hall and the character and position of the cases. It is hoped that it will provide in the most effectual manner for the display of the specimens, along with the greatest possible facilities for their scientific study. The Museum will thus afford advantages for the study of Geology and Natural History not previously enjoyed in this country.

Provision has been made on the ground floor for a large and well-arranged lecture theatre and two class-rooms, which will also afford space for reference collections for the use of lecturers and students, and for the herbarium. In the basement there is a large laboratory for the preparation of specimens, and ample space for the storage of material.

It is proper to add that while Mr. Redpath has kindly undertaken to bear the current expenses of the New Museum for a few years, no special provision exists for the work of teaching within its walls, except the very inadequate amount afforded by the endowment of the Logan chair of Geology. Endowments are urgently required for Mineralogy, Botany and Geology, and it is hoped that the example of Mr. Redpath may stimulate other benefactors to supply these deficiencies. Aids of this kind would also relieve the general funds of the University.

It should further be borne in mind that the erection and endowment of the Peter Redpath Museum affords an illustration of what may be done by other benefactors for the departments of Physical and Chemical Science, and for our Faculty of Applied Science. Each of these requires for its full development buildings and endowments. In connection with this I have pleasure in stating that A. C. Hutchison, Esq., one of the architects of the Peter Redpath Museum, proposes to prepare a plan and elevation showing how the buildings required in the future for the above and other University purposes may be erected in due relation to the present buildings, and in harmony with the plan of the new Museum.

It is proposed that Reports on the Museum shall be printed from time to time, recording its progress; and that in future these shall include lists and short descriptions of new species, and statements of new scientific facts which may be discovered. Some unpublished material already exists in the collections, and has been laid aside for description, and it is hoped that future reports may shew that the museum, in addition to its educational work, will be a means of advancing the knowledge of Canadian geology and natural history.

NATURAL HISTORY SOCIETY PROCEEDINGS.

The third meeting of the session 1881–82 was held on Monday evening, December 15th—Principal Dawson in the chair.

The following gentlemen were proposed as ordinary members of the Society:

Rev. Dr. Sullivan.
D. J. Greenshields.
M. H. Gault, M.P.
J. Hodgson.
R. L. Gault.
E. R. Greenshields.
Geo. Sumner.
G. A. Greene.
Jacques Grenier.
H. A. Nelson.
R. Reford.
H. Shorey.
A. M. Cassils.
Jas. Wilson.
J. E. Moss.
T. L. Harrison.
Richard White.
R. Wolff.
Alfred Wright.
Dr. Geo. Ross.
Jno. McDougall.
Jas. Ewan.
Wm. Angus.
W. Roach.
D. Morrice.
Geo. Boulter.
A. M. Foster.
Benj. Tooke.
J. W. Mills.
Anthony Force.
Thos. Trumble.
Jno. Stirling.
Alex. McPherson.
A. F. Gault.
E. W. Gnaedinger.
A. S. Ewing.
Jno. Beattie.
Jno. Hope.
J. C. Holden.
W. T. Costigan.
W. J. Ingram.
Jas. Corristine.
W. Tees.
Hugh Graham.
Fred. Boas.
Jno. Fulton.
A. Ramsay.
J. W. Tester.
Hugh Watson.
Jas. Gardner.
Jno. Lewis.
Wm. McLaren
Jas. Stewart.
W. Wilson.
J. R. Wilson.
Geo. Hague.
D. Yuile.
Jos. Barsalou.
Thos. Montgomery.
M. McCready.
Jno. Ogilvy.
D. Torrance Fraser.
J. B. Picken.
R. C. Jamieson.
S. H. Ewing.
J. A. Harte.
T. J. Dawson.
Wm. Eward.
Adam Darling.
C. Cassils.
S. C. Stevenson.
J. H. Semple.
C. McArthur.
H. Birks.
H. Saunders.
Jno. Blyth.
C. R. Black.
Wm. Minto.
Jno Fair.
H. D. Moss.

The members then adjourned to the museum, where the Cabinet-keeper pointed out changes and improvements that had been made, and called attention to specimens recently added.

The fourth meeting was held on 30th January. The President occupied the chair. The gentlemen proposed at last meeting were elected, and the following proposed for election :

Hon. J. R. Thibaudeau.	Jas. Hutton.
F. W. Hughes.	Col. E. A. Whitehead.
J. S McLachlan.	W. Simpson.
S. Greenshields.	Robt. Linton.
W. J. Patterson.	Jas. Donnelly.
E. N. Heney.	P. J. Martin.
A. Racine.	J. A. Robertson.
J. H. Starns.	Jno. McLean.
A. L. Lockerby.	Jacob Wilson.
R. W. McDougall.	J. M. Kirk.
Wm. Darling, jr.	J. B. Sutherland.
Geo. Lightbound.	Geo. Bourgoin.
Louis A. Brais.	Arch. Campbell.
Reid Taylor.	J. H. Mooney.
G. R. Prowse.	A. W. Atwater.
Geo. Barry.	W McLea Walbank.
A. N. De la Motte.	

Mr. Henry M. Ami, student-in-arts at McGill then read a very interesting paper on the "Utica Slate Formation in Canada," with special reference to the deposits occurring in the vicinity of Ottawa city, where the writer of the paper has been making investigations and collecting specimens for the past three years.

In the course of the paper, the origin, the mode of deposition, the mineral and the lithological characters, as well as the fossils of that formation, were considered. Some new and interesting notes on *Triarthus spinosus* (Billings) were given. Several species were added to the Canadian list of fossils from the Utica slate. In the list of fossils appended to the paper, sixty-six (66) species were given as occurring in different localities throughout Canada of which only thirty-two have been previously recorded. It was also mentioned that in the United States the total number of species belonging to that formation, as recorded by Mr. C. D. Walcott was exactly one hundred, and that consequently the diligent searcher of Canada should be amply rewarded, as there remain still some thirty-four (34) species to fill up our list and make it as complete as that of the United States.

Dr. Dawson then made some remarks concerning the whale at that time on exhibition in the city, showing the difficulty of classifying the whales on account of our meagre knowledge of specific characteristics. Total length of specimen is 48 feet, circumference 20 feet. Its head is 11 feet in length, with lower jaw wider and deeper than upper.

[The balance of Proceedings to date is left over to next number through want of space.]

Published 25th April, 1882.

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

ON THE SURFACE GEOLOGY OF THE BAIE DE CHALEUR REGION.

By Robert Chalmers.

(Read before the Natural History Society of New Brunswick, Feby. 7th, 1882.)

In a paper which I had the honor to read before this Society in March, 1881, on "The Glacial Phenomena of the Baie de Chaleur Region," * I described the glaciation of that district, so far as it came under my notice, and also treated of the distribution of the till or glacial drift and the kame deposits within the same area. I now purpose bringing before you some facts relating to the stratified marine clays and sands which form a series of deposits skirting that body of water and the estuaries connected with it, and shall also refer briefly to the recent formations and the evidences of a subsidence of the land in the northern part of the Province. But first I shall advert to some additional observations made during the past summer on drift phenomena, chiefly in the district referred to, as tending to confirm the conclusions arrived at in my previous paper, and shall note the localities where striæ, till, etc., were met with for the first time.

GLACIAL STRIÆ.

On McPherson's farm, Charlo River, ledges of trap rock were seen, finely striated and rounded on the west side; direction of striæ east and west, referring them to the true meridian to which all the bearings given in this paper are reduced.

* Canadian Naturalist, Montreal, Vol. X., No. 1.

A mile farther east along the post road, scratches were detected on similar rocks, having a course of east and west to north 70° east. All the scratches correspond with those previously observed in this vicinity.

Between Belledune and Elm Tree Rivers the rocks are extensively glaciated along the line of the Intercolonial Railway, as stated in my former paper. A more detailed examination shows that scratches occur everywhere within this area down to the present shore of the Bay, the course being about south 80° east. To a height of 75 or 100 feet above tide level, the more exposed rock masses have the striæ obliterated, probably from the action of the sea when it stood higher relatively to the land, and these rocks were eroded by the waves and coast ice, and it is only on the low-lying ledges which have been protected by a covering of earth that the finer ice markings can be detected. Above the level stated the exposed rocks still bear traces of ice action in the *moutonné* form they present although they have been subjected to atmospheric wear for long ages.

In Robertville, which lies in rear of Petite Roche, and also in the vicinity of the so-called Nigadoo silver mines, striæ were found with nearly an east and west course. In the St. Louise settlement adjoining Robertville on the east striæ were noticed trending north 85° east to north 80° east. It would seem as if the ice sheet in its passage over this part of the district had been swerving round from a course having a southerly bearing to one north of east.

Southeast of the above-mentioned settlements in the area extending towards Bathurst and Nepisiguit River striæ were observed in a great many places, both on the front lots and also in the Dunlop, Dumfries and Tattagouche settlements, as far back from the coast as ten or twelve miles, with an average course of north 25° east. In the immediate vicinity of Bathurst however, the striæ have more northing and trend about north 20° east to north 22° east.

All these striæ afford conclusive evidence, in the rounded form of the ledges on the southwest sides, and in other respects that they were produced by ice moving towards the northeast. They likewise show a convergence towards the depression known as Nepisiguit Bay.

TILL, OR BOULDER CLAY.

In addition to the places mentioned in my former paper till was observed at Jacquet River, on the right bank near its mouth. Here it consists of a coarse, reddish clay and gravel derived from subjacent Lower Carboniferous rocks, and contains glaciated transported boulders.

It is also met with on the west side of the mouth of Nigadoo River, forming the basal portion of a bluff on the shore.

Also on the banks of the Tattagouche River, near Brown's mill, where it is composed principally of the *débris* of the granite rocks occurring in the vicinity. The river has apparently worn a passage for itself through the till at some points, as it is seen on opposite sides of the stream.

On the banks of the Nepisiguit there is evidently a considerable bed of till. This was referred to in my former paper, but a further examination during the past summer showed that my remarks are applicable only to the upper portion of the deposit, and that the lower portion is a coarse, gray, granitic *débris* packed with boulders, chiefly of granite, derived from the rocks of the neighbourhood.

The foregoing data showing the occurrence of the till along the banks of the principal rivers would indicate that it must originally have been deposited in these river valleys to a considerable depth, probably filling some of them entirely, and that it has subsequently been denuded by the action of the streams, the deposits met with on their banks now being only remnants of the original mass.

ERRATICS, OR LOOSE BOULDERS.

Great quantities of loose boulders are strewn over the surface or embedded at a slight depth in the soil, within the region embraced in my observations. In general they appear to have been shifted eastwardly or northeastwardly from the original rock. It is often very difficult to trace them to their parent beds, but in the case of the granite blocks we know of only one source whence they could be derived, namely the granite belt running southwestward from Bathurst. Now in regard to these, it may be stated that they are strewn about on both sides of the granite axis, having been met with on the northwest side at Nigadoo River and even at Elm Tree, ten miles or more from their source, becoming scarcer however, the farther we recede from the granite

in situ. On the southeast side we find them along the Intercolonial Railway and the old post road, scattered over the Carboniferous sandstones as far as the Miramichi River. Among these granite boulders we also find others of felsite, diorite, etc, which appear to be derived from the sub-crystalline belt flanking the granite on the west.

KAMES, OR SAND AND GRAVEL RIDGES.

The kame in Restigouche, described in the paper already cited, was examined more closely during the past season, and it was found that its summit, at the western extremity, was 125 to 150 feet above sea level; thence it decreased in height gradually towards the east till it ran out into a bluff on the Bay shore near Nash's Creek. Its general direction is nearly east and west, corresponding with the glacial striæ in the vicinity, but it has several lateral branches, and in a few places is spread out into level areas or terraces. These branches are often concealed from view by a covering of later deposits. Hollows, or kettle holes as they are called, were observed in this kame, especially where it flattens out, as at Black Lands and New Mills. The great road from Nash's Creek to River Charlo, 11 to 12 miles, runs along its summit nearly all that distance.

At the mouth of the Great Cascapedia River, in the Gaspé peninsula, there is a series of gravel hills, some of them assuming the appearance of ridges, which must originally have formed one continuous, well-developed kame. These hills were traced a distance of two to three miles along the left bank of the river, where they form bluffs which stand up "like a row of artificial ramparts," and increase in height as we ascend the stream. When I visited the locality last summer I had not time to follow this kame to its highest or northern extremity, but it probably extends up river a number of miles. Its average direction is about south southeast, corresponding with the course of the lower part of the river. Currents which ran transversely to its main direction have eroded it greatly in places previous to the deposition of the later stratified formations which cover it up on the eastern side to a considerable depth.

The southern extremity of this kame projects into the Bay in a bluff and exhibits a very interesting section of the deposits. The ridge is here 150 yards wide and about 40 feet in height above the beach. Like the Restigouche kame it is composed of loose

sand and gravel containing water-worn pebbles, none of them exceeding a foot in diameter. At first sight I was much puzzled with the discovery of marine fossils in the upper part of what was apparently the true kame deposits; but a closer examination soon showed me that the fossils were embedded only to the depth of from 5 to 10 feet on both flanks, and that the central portion, comprising the principal mass of the ridge, was unfossiliferous. It was seen too that while this unfossiliferous portion consisted of loose materials without clay, the fossiliferous strata held the pebbles and shells in a compact gray paste. *Saxicava rugosa*, *et* var. *arctica*, *Mya truncata*, var. *Uddevallensis* and *Macoma Grœnlandica* were the principal species observed, the first-named being the most abundant.

The occurrence of fossils in this peculiar situation suggests the question whether these shells were entombed here while the upper part of the kame was being deposited, or were they mingled with portions of it which were worked over by the sea subsequently, during the Leda clay period, when the kame became submerged. The latter seems the probable view, but the subject in my opinion, requires further investigation.

To the east of the kame occur heavy deposits of fine stratified marine sands, underlaid still farther eastward by stratified clay, reddish above and blue or dark colored below, containing marine fossils of the above-mentioned genera, and others. These marine deposits extend to the mouth of the Little Cascapedia River, three miles distant, forming terraces and concealing from view all the older formations.

A small glacier confluent with the Baie de Chaleur ice sheet, probably occupied the valley of the Cascapedia during the glacial epoch, and to its melting may be due the floods which produced the sand and gravel ridge just described. But, while attributing the formation of kames to rivers flowing over dissolving glaciers and transporting material which had accumulated on their surfaces to lower levels, the relation of such deposits to the drainage systems indicates that, in this section of the country at least, such glacial rivers have not been independent of the present water courses. The Restigouche kame is just such a deposit as the Restigouche itself would have formed were it to debouch from the hills through the Eel River gap, at a level of 125 to 150 feet above its present channel, carrying *detritus* to the flat country below; and in a similar manner the Cascapedia kame might

have originated from the action of that river. We can hardly conceive of these river valleys being filled with floods of water 125 to 150 feet above their present courses however, hence it is supposed that ice to that depth occupied them, and that the rivers flowed over its surface, laden with *débris* in sufficient quantity to form these ridges.

Some of the physical conditions necessary to the formation of these deposits, therefore, apart from the theory of their glacial origin, seem to be : (1), a considerable drainage area, affording probably a large flow of water independent of that supplied by the melting of the ice sheet; (2), a region sufficiently elevated to cause the waters to descend with great velocity; and (3), level, or comparatively level areas near the base of the hills, causing a slackening of speed in their flow and a deposition of transported material. At a greater distance than 12 to 15 miles from the elevated tract the kames disappear, and no traces of them have been observed in the flat district to the south. This cannot have arisen from lack of material to form these ridges, judging from the quantity of *débris* of a similar character found along the rivers and in terraces; but the physical conditions necessary for their development do not seem to have been favorable on the low level tracts.

GENERAL CONCLUSIONS REGARDING THE GLACIATION OF THE BAIE DE CHALEUR DISTRICT.

From facts adduced in my paper on the glacial phenomena of this region, I endeavored to show that a local glacier of considerable magnitude had once occupied the depression of the Baie de Chaleur and estuary of the Restigouche, spreading to some extent over the district bordering these waters on the south, and that the different courses of the scratches found there, proved that it had been controlled in its passage eastward by the contour of that depression. The additional data obtained during the past summer, both in regard to glacial striæ and transported material all tend to support the conclusions then reached. The average course of the Restigouche estuary is east northeast; the course of the western half of the Baie de Chaleur is east southeast or west northwest, and of its eastern half nearly east northeast or west southwest. With these bearings the glacial striæ indicate a tolerably close correspondence. The glacier seems to have moved eastwardly from the highland area in the northwest of

New Brunswick, and from the Notre Dame Mountains. It was probably made up of several smaller confluent glaciers, one flowing down the Restigouche valley from the highland regions on that river, another down the Metapedia valley from the Notre Dame Mountains, and a third down the Cascapedia valley from the Shickshock Mountains, besides others of lesser note, all coalescing in the Baie de Chaleur basin. In the list of striæ given in the Geology of Canada (1863), pages 890-92, scratches are noted as occurring on Kempt road, near Metapedia Lake, with a course of south 80° east. Metapedia Lake is about 50 miles from the junction of the Metapedia river with the Restigouche. The particular exposure of these striæ is not stated, but it is probable they have been produced by the glacier which occupied the Metapedia valley. No striæ were detected by me in any part of the Gaspé peninsula that I have visited, but the kame at the mouth of the Cascapedia, already described, may be considered evidence of a local glacier once having occupied the valley of that river.

The Baie de Chaleur ice-sheet must have overspread a portion of the Carboniferous area to the east and southeast of Bathurst, passing over it probably in a northeasterly direction. Although I did not detect any striæ on the sandstones between the Nepisiguit and Miramichi, so far as I examined them, yet the presence of numerous boulders of granite and other rocks scattered over the surface, which have been derived from the metamorphic belt to the west, may be taken as evidence of their transport by ice moving in the direction indicated.

At Weldford Station, on the Intercolonial Railway, which is about 75 miles south southeast from Bathurst, scratches occur on the Carboniferous sandstones having a course of nearly north by east or south by west. A considerable surface of rock was laid bare in this vicinity during the construction of the railway, exposing well defined striæ. They are noteworthy as showing probably the general course of the ice-sheet which passed over the flat expanse of the coal measures of the Province—Weldford being near the centre of this extensive triangular shaped area. These striæ occur on a low water shed between the valley of the St. John and the Straits of Northumberland; the Richibucto, running northeasterly from this point into the Straits, and the Salmon River southwesterly into Grand Lake. The height of the water shed is stated to be about 275 feet above sea level.

These striæ, if produced by a continental glacier, would show its normal course in this part of New Brunswick unaffected by inequalities of surface, as there are no elevations within many miles on either side by which it might be swerved. From their position on the flat ledges, it was impossible to tell from a hurried examination, in which direction the ice moved, whether northward or southward. It is probable, however, that these striæ have been made by a local glacier, and that its motion from this point at least, was southward or southwestward, perhaps along the Salmon River valley towards Grand Lake. But I would not be surprised if indications of ice having moved in a contrary direction are found in the northeastern part of the Province as at Bathurst. One thing appears certain, at all events, viz., that the striæ at Weldford have been produced by a different body of ice from that which occupied the Baie de Chaleur valley.

In concluding this part of my subject it may be stated that so far as my observations have extended in the northern part of the Province I find no evidence of the passage of a continental sheet of ice over that region from north to south. There is evidence that the land was covered down to the present sea level by a glacial mantle of considerable thickness, exceeding in narrow valleys 1000 feet, but, in general, much less on level surfaces. This covering probably existed as snow and ice and not as one solid masssive ice-sheet, the ice, when formed, becoming local glaciers. These glaciers descended the nearest slopes, seeking the lowest levels, till they debouched into the sea, or formed one large local glacier in the Bay of Chaleur basin. The courses followed by these local ice sheets conformed almost invariably in detail to the present surface features of the district, not varying far from those of the river valleys. Glacier action of this kind seems to be sufficient to account for all the observed glacial phenomena, if we except the transportation of some foreign boulders which may have been carried about by floating ice.

During the occupation of this region by an ice covering it probably stood somewhat above its present level.

STRATIFIED MARINE CLAYS (*Leda Clays*).

Stratified clays holding marine fossils in abundance are met with all around the Baie de Chaleur, forming a considerable portion of the soil of the area skirting its waters, especially near the mouths of rivers, and they have also been traced along the

banks of streams some distance from the coast. In the Restigouche valley they are found as far up as the mouth of the Upsalquitch containing shells of *Mya* and *Macoma*, but have not been detected on the higher lands of the interior. These clays, which, so far as I can judge, are equivalent to the Leda clays of the St. Lawrence valley occur usually as thin fragmentary sheets in the greater part of the district under examination, but at the mouths of the Nepisiguit, Tattagouche and Jacquet rivers, and some other places, they form local beds of considerable extent and depth. In cuttings along the Intercolonial Railway, sections of these clays were exposed during its construction, and excellent facilities afforded for studying them and collecting the fossils embedded therein. In some of the thicker beds, as at Tattagouche and Benjamin rivers, there are evidently upper and lower clays, such as have been recognised by Mr. Matthew in the south of the Province, and by Dr. Dawson in the St. Lawrence valley. The lower division is sometimes a finely laminated blue clay, the laminæ not distinctly visible, and it is usually without pebbles. In other places it is a stiff, dark gray, or brown clay, more or less pebbly and unfossiliferous. The upper division is generally a gray or brown clay, with the higher strata occasionally bluish or black, and prolific in fossils. It likewise contains pebbles and a few scattered boulders, and there are numerous proofs of its upper surface having been eroded by currents, and in some parts perhaps by tidal waters previous to the deposition of the overlying stratified sands. In many places, however, no well marked division between upper and lower beds has been detected, and the differently constituted clays graduate into each other and appear to have been closely consecutive in formation, their color and composition depending largely upon the nature of the rock-formation or drift beds whence they were derived. For example, at the mouths of rivers running through a limestone district blue calcareous clays prevail, while reddish clays are invariably met with in districts in which red Lower Carboniferous sandstones occur. In localities where the clays overlie kame deposits they are so thickly packed with boulders and material derived from the latter as to be scarcely distinguishable were it not for the contained fossils.

The entire thickness of the Leda clays, upper and lower, where they have their greatest development, as in the neighborhood of Bathurst, is about 75 feet, and on the banks of the Tattagouche

River they attain a greater elevation than elsewhere in the district, rising to a height of nearly 100 feet above sea level. Their vertical distribution, however, must exceed this considerably, for in many places they are seen sloping down beneath the waters of the Bay, as for instance, at Charlo and Jacquet Rivers, and the mouth of the Great Cascapedia, where a tough blue or blackish clay is exposed at ebb-tides, enclosing fossils in abundance.

The marine fauna embedded in the Leda clays of the Baie de Chaleur is largely of an arctic type. Some years ago I made a collection of shells from these beds, which was submitted to my friend Mr. Geo. F. Matthew, of St. John, who published a list of them in one or two papers relating to the Post-Pliocene of the Bay of Fundy region.* I here reproduce the list:

Saxicava rugosa, Linn.
" var. *arctica;* abundant.
Mya truncata, Linn; scarce.
" var. *Uddevallensis;* common.
M. arenaria, Linn.
" var. *acuta*, Say; abundant.
Macoma calcarea, Chemnitz.
M. Grœnlandica, Beck; common.
Serripes Grœnlandicus, Chemnitz.
Kellia suborbicularis, Montagu; rare.
Mytilus edulis, Linn; scarce.
" var. *elegans;* common at Benjamin River and Black Point.
Nucula expansa, Reeve; very rare.
N. tenuis, Montagu; common.
Leda pernula, Muller, var. *baccata;* very plentiful.
" var. *tenuisulcata.*
L. minuta, *Fabricius*, var. *caudata.*
Portlandia glacialis, Gray.=*Leda truncata*, Brown; not common except at Jacquet River.
Yoldia sapotilla, Gould.
Bela harpularia, Couthuoy.
B. turricula, Montagu; common.
Natica affinis, Ginelin,=*N. clausa;* abundant.
Lunatia heros, Say.
" var. *Chalmersi*, Matthew; rare.
Buccinum Grœnlandicum, Chemnitz?
B. tenue, Gray.

* *Canadian Naturalist*, Vol. VIII, No. 2; also in an article on the Superficial Geology of Southern New Brunswick, Report of Progress, Geological Survey of Canada, 1877-78.

B. glaciale, Linn.
B. undatum, Linn; frequent.
Tritonofusus Kroyeri, Muller.
Fusus tornatus, Gould.
Balanus crenatus, Brug; very abundant.
B. Hameri Ascan; rare.

In the Jacquet River beds the remains of a small cetacean were discovered about 25 feet above sea level in a clay cutting of the Intercolonial Railway. Nearly the whole skeleton was obtained which was sent to Halifax and identified by Drs. Gilpin and Honeyman as that of *Beluga Vermontana*, Thompson. In the Tattagouche clays, Rev. C. H. Paisley found *Eurychinus Drobachiensis*, Muller (*Echinus granulatus*), two species of *Spirorbis* and remains of the eel grass, *Zostera marina* L. and of *Equiseta* in addition to the above. And during the past summer I discovered a portion of the claw of a lobster (*Homarus Americanus* Edw.) at Black Point, Restigouche County, in a situation which made me almost certain it was in the fossil state, as it was embedded in a heap of clay washed out of the side of a railway cut and associated with fossil shells of *Saxicava rugosa*, *Mya arenaria*, *M. truncata* var. *Uddevallensis*, etc. The specimen has a battered, worn appearance too, and looks as if it might be as old as the shells, nevertheless until others shall have been found, I would not care to make any positive assertions about it.

The fossils in the Leda clays of this district are all remarkably well preserved, and many of them occur apparently in their natural situation, especially in the lower clays; but, from the manner in which they are distributed, deep water and littoral species often appearing intermingled in the same beds, their value, as indicative of the depth of water in which they lived, is not to be greatly relied on. Nevertheless some deductions may be drawn from them regarding the climate and temperature of the seas at that period. At Charlo River the shells occur in blue clay, below high-water mark, and a majority of the species are arctic. They probably lived in waters of moderate depth. *Balanus crenatus* and *Saxicava rugosa* are the most abundant forms, but *Leda pernula*, *Tritonofusus Kroyeri*, *Nucula tenuis* are also frequent, especially the last, while *Portlandia glacialis* is rare. The two first mentioned species (*Balanus crenatus* and *Saxicava rugosa*) must have found a congenial *habitat* in these seas

in the Leda clay period, as they abound throughout the deposits of the Baie de Chaleur basin. In the Benjamin River beds the littoral species *Mytilus edulis* var. *elegans*, *Mya arenaria* and others predominate, particularly in the upper strata, and appear to range upwards into the stratified sands overlying them. *Serripes Grœnlandicus* and one or two species of *Natica* are also common, and the deposits are evidently of shallow water origin. At Black Point the prevailing forms are also such as inhabited comparatively shallow seas. *Mya truncata* var. *Uddevallensis* is common, and a variety of *Mytilus edulis* and *Mya arenaria* likewise occur here in strata graduating into the sands. *Balanus crenatus* is especially abundant, the upper part of the clay being literally packed with fragments of it; and the lobster (*Homarus*) which probably inhabited the Baie de Chaleur in later Post-Pliocene times is apparently to be met with in these deposits. But the presence of several Arctic *Buccina* (*B. tenue*, *B. glaciale*) and *Tritonofusus Kroyeri*, besides *Portlandia glacialis*, *Leda minuta*, *Macoma calcarea* and others indicate colder and deeper waters and climatic conditions, similar to those of high latitudes, in the Leda clay period previous to the existence of these littoral species. It may be stated that the clay containing these fossils at Black Point rests on the flanks of a kame, has a sloping attitude, and is packed with sand, gravel and pebbles derived from it, as is also the formation overlying the clay corresponding to the Saxicava sands. Were it not for the presence of the fossils which can be traced along certain strata the whole might readily be taken as constituting the kame, as is the case at the mouth of the Cascapedia already referred to.

The fossils embedded in the clays of Jacquet River imply deposition in deeper or colder waters than those found elsewhere on the coast, if we are to judge from the occurrence of such species as *Portlandia glacialis*, *Leda pernula* and *L. minuta* of Dawson's lists in considerable abundance and in a good state of preservation. In the upper strata however, *Mya arenaria* and *Saxicava rugosa* come in, in full force. The skeleton of *Beluga Vermontana*, already spoken of, was found here near the surface of the clay.

The deposits at Tattagouche and Bathurst afford typical examples of Leda clays and Saxicava sands, the latter, however, unfossiliferous. Rev. C. H. Paisley published a description of these beds in the *Canadian Naturalist*, Vol. VII. No. 5.

In regard to the conditions of the formation of the Baie de Chaleur Leda clays, it may be stated that at whatever depth of the sea the lower clay was deposited (and it appears probable that it was laid down in waters not deeper than the Baie de Chaleur is at the present day, namely 20 to 30 fathoms), the higher strata bear evidence of having been formed in shallow waters. For, not only has the upper surface of the clay been eroded and channelled by currents previous to the deposition of the marine sands, but the fossil shell themselves in many cases indicate that they were washed about by the sea and thrown together in masses, occurring often compacted two or three inches deep with the valves mostly separated and broken. Occasionally, too, they seem to occupy pockets or holes in the upper part of the clay, and are heaped up sometimes on one side or the other of the larger boulders. The frequent commingling of deep water and littoral species may thus be accounted for, the sea having washed those from shallower waters into greater depths, and *vice versâ*.

But although the assemblage of shells embraced in the foregoing list does not afford conclusive testimony as to the depth of the sea in the Post-Pliocene period, yet it is of value as showing that the climate and the waters of the Baie de Chaleur region were much colder then than now. The shells imply, indeed, a temperature boreal or subarctic in charater, similar to that of Labrador or the south of Greenland at the present day; nearly all the species mentioned being now found in the seas adjoining these countries at moderate depths. Their occurrence at the Baie de Chaleur may be explained by supposing that the land stood 100 to 150 feet below its present level, thus allowing the cold waters of the arctic current to circulate freely in the southern part of the Gulf and tenant it with such species as are now found only in extreme northern latitudes. But the fact that the fossils are met with chiefly in the beds which have accumulated at or near the mouths of rivers would lead us to infer that the cold fresh waters which must have poured into the bay in great quantities during the time of their existence have had a greater or less effect upon them; and their irregular forms, the strength and thickness of the shells, as well as their abundance are probably due to that and other local causes. The purely arctic fauna of the lower Leda clay may have lived in the Baie de Chaleur before the final retreat of the glaciers.

Since the deposition of the Leda clays the great change which has taken place in the climate of the district has driven these arctic marine animals northwards into the cold seas above mentioned, and their place has been taken up by a more southern assemblage. The only marine shells of these clay beds living in the Baie de Chaleur now, so far as I have been able to ascertain, are *Mya arenaria*, L, *Mytilus edulis*, L, *Macoma fusea*, Gould, which is perhaps identical with *M. Grœnlandica*, Beck, of Post-Pliocene date, *Lunatia heros*, Stimp. and *Buccinum undatum*, *L*; while the following species, the largest proportion of which are of a New England type and do not occur in the Leda clays, so far as known, are now found there:

Cardium pinnulatum, Conrad.
Pecten tenuicostatus, Mighels and Adams.
Mactra solidissima, Chemnitz ; abundant.
Modiola modiolus, Turton ; common.
M. —— *plicatula*, Lam.
Solen ensis, Lam ; common.
Machæra costata, Gould ; rare.
Callista convexa, Say ; frequent.
Venus mercenaria, Lam ; abundant.
Crepidula fornicata, Lam ; common.
Ostrea borealis, Lam ; plentiful.
Aporrhais occidentalis, Sowerby.
Littorina palliata, Gould.
Tectura testudinalis, Stimp., etc.

A comparison of this list, meagre as it is, with that of the shells belonging to the Leda clays, given on a previous page, shows at a glance the difference between the faunæ of the Post-Pliocene and the Recent periods in the Baie de Chaleur. The amelioration of climate which brought about this change took place along with a rising of the land and a shallowing of the seas around the shores of Acadia. Dr. J. W. Dawson infers, with much probability, that the invasion of Acadian waters by these New England species occurred in the modern epoch. It is a singular fact, ascertained by dredgings made in different parts of the Gulf of St. Lawrence, that that part of it lying to the south of a straight line drawn from Cape Breton to Gaspé, and to which Dr. Dawson has given the name of the Acadian Bay, is inhabited by a colony of marine forms of a southern type (examples of which are found in the Baie de Chaleur) cut off from their relatives on the New England coast by intervening cold waters. To explain

this phenomenon, this distinguished geologist concludes that when the land was at its highest level in the modern period—and stood considerably above the height at which it now is—the waters all around the coast of Nova Scotia and Cape Breton were warmer owing to the arctic current being thrown farther from the shore, perhaps outside of the banks, and these marine animals would then emigrate thither from the south and spread themselves into the Acadian Bay. The subsidence which has since set in has caused the arctic current to run more closely to the shores of Nova Scotia and Maine, this southern fauna has begun to retreat, and those species inhabiting the waters surrounding Prince Edward Island and in the Baie de Chaleur have thus become isolated.

STRATIFIED MARINE SANDS, SEA-BORDER TERRACES, ELEVATED BEACHES, ETC.

Stratified sands occur almost everywhere within this region and overlie the Leda clays in most places to a greater or less depth. The lower portion of these deposits is probably equivalent to the Saxicava sand of Dr. Dawson, but no fossils have been detected in them, except it is *Mytilus edulis*, var. *elegans*, which, at Benjamin River and Black Point seems to extend upwards from the Leda clay into their lowest strata. These sands attain their greatest development near the mouths of the larger rivers, forming in some places extensive stratified beaches, or with the underlying stratified clays have been sometimes shaped into a series of terraces, the higher, altogether of sand and perhaps gravel, the lower, Leda clay with a sheet of sand occasionally covering them. At Bathurst there is a large area between the harbor and the Tattagouche River, extending westward to the St. Ann settlement covered with these sands, making a terrace 125 to 150 feet above sea level. This terrace or sand flat is the highest in the region and appears to have derived the material composing it largely from the rivers which here empty into the Bay, in a similar manner to extensive sand flats or shoals now in process of formation outside of the harbor. One or two lower terraces are seen in this vicinity, but their upper surface is very uneven and seems to correspond with that of the Leda clay beds, the sands which once covered them having been denuded to that level. Near Jacquet and Charlo Rivers and Nash's Creek are smaller areas of elevated beaches at a less height above the sea, and around the

estuary of the Restigouche there are similar formations, especially at the mouths of tributary streams.

The material of the higher terraces is often a fine stratified gray or bluish gray sand, in some places changing to a brown or reddish sand, and near its upper surface containing water-worn pebbles occasionally arranged in layers. In parts of the country where these sands are not arranged in terraces they are stony, and vary in character from a fine quartzose sand to coarse gravel and boulders. Where they are found overlying or flanking the kame deposits they are composed largely of material derived from them, rendering it often difficult to distinguish one formation from the other.

These marine sands have not been observed at a greater height than 125 to 150 feet above the sea, and their extreme thickness does not exceed 50 to 60 feet. They graduate almost imperceptibly into the recent marine sands composing the present beaches and sand dunes.

The terraces in the marine beds of this district are usually three in number, the highest 125 to 150 feet above tide level as already stated, and the two lower at about 70 to 75 feet and 25 to 30 feet respectively. The last two have been formed by erosion of the stratified clays and sands as the land rose. And it would really seem as if their had been a pause at intervals in the upward movement, allowing greater denudation and terrace making along sea borders at certain levels, although these phenomena can, in several places, be accounted for by the looseness or weakness of the strata at these levels, and their compactness or power of resisting erosion at others. A 14 to 15 feet terrace was observed in some of the estuaries, and also others at less heights. The 125 to 150 feet terrace is the most extensive, and seems to be the upper limit of the marine formations on the southern side of the Baie de Chaleur during the Post-Pliocene epoch.

FRESH WATER FORMATIONS, RIVER TERRACES, ETC.

Besides the deposits just described consisting of stratified marine clays and sands, other beds are met with on the higher lands and more especially in river valleys in the interior, which have evidently been formed by the action of water, but bear no traces of marine life. The great bulk of these deposits is sand and gravel, with layers of clay or loam sometimes interstratified,

or occasionally in beds of a few feet in thickness sufficiently pure for brickmaking. Along the banks of rivers they form terraces. These terraces are a conspicuous feature of the scenery on the Upsalquitch River and upper Restigouche, but nowhere in our Province are they exhibited on such a grand scale as along the upper St. John between Fredericton and Grand Falls. The material of the highest of these terraces having a flat summit seems to be chiefly sand and gravel, and has a close resemblance to that of the kames. This upper terrace marks the highest continuous flood plain of the river at the close or immediately subsequent to the melting of the ice-sheet of the glacial epoch. The lower terraces (there are generally three or more) have been formed by erosion of the upper or all other terraces of a higher level through the action of the river. And owing to the diminished volume of water as well as to other causes the materials composing these lower terraces are usually finer, with greater quantities of sand varying to loam or clay in places where the river valleys are wide and the current slow enough to permit quiet deposition of sediment. An elevatory movement of the land is not necessary to the formation of river terraces which are beyond the reach of the sea, although by increasing the speed of the currents it may give the rivers greater erosive power. Terrace-making is still going on along our river valleys though apparently at a greatly reduced rate.

This portion of the stratified deposits, that is to say, the upper terraces, or remnants of the highest flood plains of our rivers, has, as already stated, a marked lithological resemblance to the kame deposits and is obviously related to them in origin. The larger boulders often found in the kames do not, however, occur in the terraces. Besides the latter contain clayey strata sometimes near the bottom, not met with in the Kames. But the character of the earth, gravel and stones composing them, their structural arrangement, as well as their height above the present water courses are striking points of similarity, and indicate deposition also from great floods which swept down these river valleys immediately after the retreat of the ice-sheet,—floods so immense as to be out of all proportion to the present streams. What the exact relations are between these river gravels and the kames, however, is a question demanding closer investigation than I have been able to give to it; but evidently the two formations will have to be studied together.

RECENT DEPOSITS, INCLUDING SAND DUNES, MARL AND PEAT BEDS, ETC.

Recent deposits of marine or estuarine origin occur at Bathurst, at the mouth of the Restigouche and elsewhere, and sand dunes or "points," as they are called, of considerable area have been thrown up at Belledune and Heron Island, and appear to be increasing in extent by the addition of fresh material at intervals. These dunes are composed chiefly of loose sand washed up by the waves; and high spring tides often roll over them leaving drift wood on their surfaces. Belledune Point is one of these formations—the largest probably in the region—and juts out into the Bay three-fourths of a mile or more. At its outer extremity it is made up largely of pebbles half an inch to one inch in diameter, while near the bank or shore the material is chiefly fine sand. A submarine rocky ledge runs out here into the Bay a few fathoms under the surface of the water, and this dune is evidently a sand flat thrown up on it as high as the sea is capable of forming sand beaches. Its shape is triangular, and the material composing it appears to have been forced up from the sea bottom at successive intervals on the northeast side of the dune into parallel ridges, their general direction being about northeast and southwest. These ridges are of various widths and elevations, but the oldest or first found are 4 or 5 feet lower than those of more recent date, yet preserve their original shape, although in spots they are covered with a scrubby growth of wood. They are protected from erosion on the northeast by a sandbank thrown up along the run of the dune, which is several feet higher than the earliest formed ridges. A comparison of the heights of all these ridges would seem to indicate a gradual subsidence of the land during the period of their formation.

Little Belledune Point affords proofs of having been similarly formed, except that the ridges extend northwest and southeast. Neither of these sand dunes is near the mouth of any river and hence, as already indicated, the materials of which they are composed must have been washed up by the force of the sea during storms from the shallow bottom surrounding them. On the opposite side of the Baie de Chaleur dunes are in process of formation at Carleton, Paspebiac and other places which are evidently referable to the same cause.

The harbor of Bathurst and the estuary of the Restigouche appear to be rapidly silting up, and great stretches of flats composed of sand, clay and mud are exposed at ebb tides covered with a growth of seaweeds, chiefly *Zostera marina* and *Ruppia maritima*. The old settlers report these basins as getting shallower within the last fifty years, and this fact has given rise to the opinion by some geologists that the land was rising in the Baie de Chaleur district; but the filling up of these estuaries seems to be entirely due to the *detritus* carried down by the rivers.

Near Belledune Point, on the farm of Mr. Hugh Galbraith, there is a peat bog skirting the shore, the seaward border of which is now being covered over with sands washed up by the waves. The peat is 4 to 5 feet in depth and is underlaid by marl containing fresh water shells *i.e. Limnœa*, *Planorbis* and others. Dr. Gesner refers to this deposit in one of his Reports, and says it must have once formed the bed of a fresh water lake. Portions of it are now being converted into salt marsh.

Along the shore to the south of River Charlo and elsewhere within this region are similar beds of peat, which are apparently being encroached on by the sea.

High tides seem also to encroach farther on the land of late years than formerly, eroding the banks and throwing up sand higher than has been known since the settlement of the country. One of these high tides accompanying an easterly storm occurred in October, 1861, and washed away from 10 to 15 feet of the banks on exposed parts of the coast, spreading so much sand and *débris* over the fields along the shore as to render some of them unfit for cultivation since.

These phenomena together with the apparent sinking of the sand dunes referred to would indicate that the region is slowly subsiding since the formation of the peat and marl beds.

I shall conclude this paper with a section of the surface deposits of the Baie de Chaleur district, embracing a synoptical statement of their geological history, so far as known to me, in descending order.

(1) Recent Deposits.—On the coast—sand dunes, estuarine silts, submarine sand flats. In the interior—river intervales and alluvia, peat and marl beds, etc. Life during period of these formations—fresh water shells. Land reaching a height above present level, followed by a gradual subsidence.

(2) Stratified Marine Sands.—Saxicava sands. Marine formations were—sea-border terraces, raised beaches. In the interior—river terracing. No fossils of the period in this region. Land rising: marginal marine areas emerging from beneath the sea.

(3) Leda Clays.—Upper red or brown clay, formed in comparatively shallow waters. Contains pebbles and remains of an abundant marine life. Lower Leda clay—blue or dark colored, fewer pebbles and fossils: chiefly arctic species. Waters of moderate depth, probably 20 to 30 fathoms. In the interior—terrace-making along rivers. Land rising. Climate subarctic.

(4) Kame Deposits, and material of river terraces, the latter now seen in the upper terraces. No organic remains. Land probably subsiding, though not far from its present level.

(5) Till or Boulder Clay.—Irregularly distributed, occurring on borders of river valleys and under lee of elevations. Evidently of glacial origin. Boulders or erratics strewn about which have been transported by ice. No fossils. Greater portion of till, apparently upper till of other regions. Land evidently above the present level.

SURFACE GEOLOGY OF THE REGION ABOUT THE WESTERN END OF LAKE ONTARIO.

By J. W. Spencer, B.A.Sc., M.A., Ph.D., F.G.S.,
Vice-President of the University of King's College, Windsor, Nova Scotia.

(This Paper is Part II. of the "Geology of the Region About the Western End of Lake Ontario." For Part I., see this Journal, Vol. X., No. 3.)

I.—INTRODUCTION.

We have seen in Part I. of the "Geology of the Region about the Western End of Lake Ontario" that a large and varied study may be made out of the exposures of the old rock-formations. In the present portion of the study, it will be found that the *Surface Geology* is not only of local interest, for, from it we are taught many things concerning the vexed subject of glacial geology;—about the origin of the Lower Great Lakes, the terraces and the transportation power of pan or floe ice, besides the physiography of the region before the advent of the Ice Age and especially the causes which combined to form this very picturesque region of Canada.

In Part I, on the Palæozoic Geology, a portion of the surface features were described with reference to the exposures of Palæozoic formations. The present descriptions of topography have reference only to the Surface Geology.

In order to more fully explain the causes which conspired to bring about the present features, it is necessary to wander somewhat beyond the Region about the Western End of Lake Ontario. The descriptions of the topography and a portion of the study of the origin of the Lower Great Lakes have already been published *

* "Discovery of the Preglacial Outlet of the Basin of Lake Erie into that of Lake Ontario; with Notes on the Origin of our Lower Great Lakes." By J. W. Spencer, B.A.Sc., Ph.D., F.G.S., King's College, Windsor, N. S. Read before the American Philosophical Society, March 18, 1881, and published in the Proceedings of the Society. The same paper was re-published in Report Q., of the Pennsylvania Geological Survey, with Notes by Prof. J. P. Lesley, the Director. A portion of the paper on the Origin of the Lakes is copied from my Paper on the subject, read before A.A.A.S., Cincinnati, Aug., 1881.

but will here be reprinted with some alterations without quotation marks.

II.—TOPOGRAPHY OF THE REGION ABOUT THE WESTERN END OF LAKE ONTARIO.*

The Niagara Escarpment.—This range of hills commences its course in Central New York, and extends westward, at no great distance south of Lake Ontario. It enters Canada at Queenston Heights, and thence its trend is to the western end of the lake, where, near Hamilton, it turns northward and extends to Cabot's head and Manitoulin island. Everywhere in Canada, south of Lake Ontario, it has an abrupt fall looking towards the northward; but at Thorold and other places to the eastward its brow is more broken than at Grimsby, and westward. At Hamilton the brow of the escarpment varies from 388 to 396 feet above Lake Ontario. About five miles east of Hamilton the escarpment makes an abrupt bend enclosing a triangular valley, down which Rosseaux creek and other streams flow. This valley is about two miles wide at its mouth, and has a length of about the same distance.

About five miles westward of Hamilton the Niagara escarpment becomes covered with the drift deposits of a broken country, or rather ends abruptly in the drift of the region. Above the range, the country gradually rises to the divide between Lake Ontario and the Grand river, or Lake Erie, without any conspicuous features. South-eastward of Hamilton, at a point about five miles from the brow of the escarpment, where the Hamilton and North-Western Railway reaches the summit, the altitude above Lake Ontario is 493 feet. At Carpenter's quarry, two miles southward of the "mountain" brow, at the head of James street, the altitude reaches 485 feet; and near Ancaster the summit is 510 feet above Lake Ontario. From eastward of Grimsby (for twenty miles) to near Ancaster, the escarpment presents an abrupt face from 150 to 250 feet below the summit (having a moderate amount of talus at the base), thence it extends by a more or less steep series of slopes to the plane, which gradually

* The topography is partly represented on map accompanying Palæozoic Geology. Burlington Heights is the spur of land between the Marsh and Burlington Bay.

inclines (sometimes by a succession of terraces), to the lake margin.

On the northern side of the town of Dundas, the abrupt face of the escarpment looks southward, and extends four or five miles westward, until the exposure becomes covered by the drift deposits near Copetown station, similar to the termination at Ancaster on the south side of the Dundas valley, but not by an abrupt ending as at the latter locality. About two miles east of the G. W. Railway station, at Dundas, the trend of the range bends more to the northward, and from this point there is a marked difference in the configuration of the country below the summit. The range, after extending beyond Waterdown, turns still more to the northward and passes near Milton and Limehouse station (on the G. T. Railway), and thence extends to Georgian bay. The height of Copetown above the lake is 502 feet. On the west side of Glen Spencer it is 409 feet, and eastward of the same gorge, the highest point is 520 feet (Niagara limestone coming to within four feet of the surface). At Waterdown the altitude is over 500 feet (?) and at Limehouse the brow of the range (though only the lower beds of the Niagara limestones occur) is 810 feet. Farther to the northward the country rises until it reaches an altitude of 1462 feet above Lake Ontario, or 1709 feet above the sea, near Dundalk station, on the W. G. & B. Railway. The features of the surface of the country above the highlands north of Dundas are much more varied than south of Dundas valley. As the trend of the escarpment turns northward around the end of the lake, the face of the slope looks towards the eastward.

*Basin of Lake Ontario.**—As is well known, Lake Ontario consists of a broad shallow (considering its size) basin, excavated

---

* The various Canadian railways and canals, whose elevations are referred to sea level, take Lake St. Peter as the datum. This represents high tide in the St. Lawrence River. The elevation assigned to Lake Ontario is 235 feet (by the Grand Trunk Railway) and 232 feet, according to different Canadian authorities, (above Lake St. Peter). The U. S. Lake Survey places Lake Ontario at 246·91 feet, and Lake Erie at 573·60 feet above mean tide. The Welland Canal places Lake Ontario at 326·75 feet below Lake Erie (which is now generally acknowledged to be 573 feet above mean ocean level). Therefore in all future references to elevation above mean tide, I have taken Lake Ontario at 247 feet.

on the southern margin out of the Medina shales, and having its southern shores from one to several miles from the foot of the Niagara escarpment. The Medina shales form the western margin (where not covered with drift) to a point near Oakville. From this town to a point some distance eastward of Toronto, the hard rocks are made up of the different beds of Hudson River epoch; while the soft Utica shales occupy the middle portion, and the Trenton limestone the portion of the Province towards the eastern end of the lake.

The country at the western end of the lake consists of slopes gently rising to the foot of the Niagara escarpment, noticed before. Sometimes this elevation is by terraces, and again by inclines so gentle, as between Lake Ontario and the foot of the escarpment at Limehouse (on the G. T. Railway) where the difference of altitude above the water is more than 700 feet, without any very conspicuous features.

At the western end of the lake, the two shores converge at an acute angle. At about five miles from the apex of this angle is the low Burlington beach, thrown across the waters in a slightly curved line, which forms the western end of the open lake. Burlington bay, thus formed, is connected with the open lake by a canal of the same name. This beach is made up of sand and pebbles (mostly of Hudson River age), and is more than four miles long, but nowhere is it half a mile wide.

No mean depth of Lake Ontario can be fairly stated. For geological purposes it has no mean depth, because it is simply a long channel with the adjacent low lands covered by back-water.

West of the meridian of the Niagara river the lake is evidently filled with more silt than eastward, as we find that the bottom slopes more gradually towards the centre, where the mean depth (increasing from the westward) of the channel may be fairly placed at 400 feet below the present surface of the waters. In this section of the lake, the average slope from both shores may be stated at 30 feet in a mile. At a short distance east of the 78th meridian, the character of the lake bottom changes in a most conspicuous manner. Here we find a deeper channel which extends for more than ninety miles, having an average depth of about 90 fathoms or 540 feet, with, in some places, a trough about 600 feet deep, generally near the southern margin of the

90-fathom channel. Here and there is a deeper sounding—the deepest being 123 fathoms or 738 feet. The long channel, surrounded by the 90-fathom contour line, is situated at a mean distance of not less than twenty miles from the Canadian shore, whilst its southern side approaches in some places to within six miles of the American shore, with which it is parallel. This 90-fathom channel varies from three to twelve miles in width. Its broadest and deepest portion is south of the Canadian peninsula of Prince Edward's County.

The mean slope of the lake bottom, from the Canadian shore to this deep channel just pointed out, may be placed at less than twenty-five feet in a mile, with variations from twenty to thirty feet in that distance. The mean slope from the New York shore line to the 90-fathom channel may be placed at sixty feet in a mile, but varying generally from fifty to ninety feet. On examination we find that the greater portion of this slope belongs to a belt which descends much more rapidly than the off-shore depression.

That the southern side of Lake Ontario has a submerged series of escarpments or one moderately steep and of great dimensions, is manifest when we come to study the soundings. In fact, if the bed of Lake Ontario were lifted out of the water, this submerged escarpment would be more conspicuous than the greater portion of the present one, known by the name of the Niagara. In many places the descent from the table-land above the Niagara escarpment is no more precipitous than the slopes of the submerged Cambro-Silurian (Hudson River, in part, if not throughout the entire length) rocks, with its sloping summit, in part crowned by a gently sloping surface of Medina shales. Nearly north of the mouth of the Genesee river, we find that within a single mile the soundings vary from forty-three to seventy-eight fathoms (between contour lines). This gives a sudden descent in one mile of 210 feet. As the soundings are not taken continuously to show to the contrary, most of the change of levels may be within a few hundred yards.

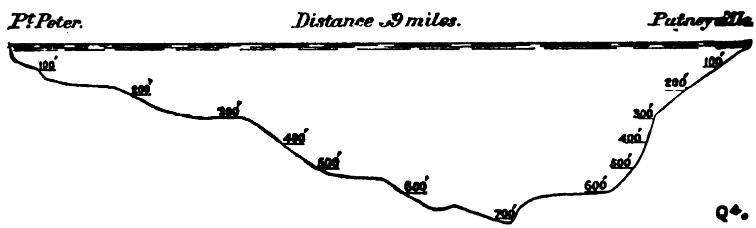
In the region of these soundings the deepest water outside of the 78-fathom line is 84 fathoms, whilst from the shore to the 43-fathom sounding the least distance is four and a half miles, thus giving the greatest mean slope of the lake bottom at sixty feet in a mile, before the escarpment is reached.

An excellent series of soundings can be studied in a line nearly northward from Putneyville, N. Y.:

Distance from Putneyville.		Depth of Sounding.	Slope from previous Sounding.
0.5 miles.		42 feet.	
1.0 "		72 "	60 feet per mile.
1.75 "		126 "	72 " "
4.125 "		246 "	50 " "
5.0 "	Face of the esc'pment.	372 "	144 " "
6.0 "		582 "	210 " "
7.0 "		624 "	42 " "
10.0 "		642 "	6 " "
12.0 "		738 "	48 " "

Fig. 1.

Section of Lake Ontario from Point Peter Light, Ontario, to Putneyville, N.Y.



Q4.

From this table it will be seen that in a distance of less than two miles the slope of the escarpment is the difference between 582 and 246 feet, or 336 feet as actually recorded. At Hamilton, the Niagara escarpment is only 388 feet above the lake, which is two miles distant, whilst the present slope at Thorold is spread over nearly twice that distance. That this escarpment is not local is easily seen. For a distance of over forty miles, from near Oswego westward, it plunges down 300 feet or more in a breadth varying from less than two to three miles. Eastward and westward of this portion of the lake this submerged escarpment can be traced for nearly one hundred miles, but with the portion deeper than the 70-fathom contour having more gradual soundings, as the base of the hills either originally had a more gradual slope, or the lake in its western extension has subsequently been filled with more silt.

Although we have not soundings made very close together, yet the admirable work of the United States Lake Survey is more than sufficient to prove the existence of a continuous escarpment which has an important bearing on the Preglacial geography of the

region, and on the explanation of the origin of the Great Lakes themselves.

The soundings do not show a conspicuous escarpment after passing westward of the meridian of Niagara river, partly on account of the sediments filling this portion of the lake, and partly because the lake in all probability never had its channel excavated to so great a depth as farther eastward.

Attention must be called to the fact that the depth of the Niagara river is 12 fathoms near its mouth, but that the lake around the outlet of the river has a depth not exceeding four fathoms with a rocky bottom.

Another escarpment at the level of Lake Ontario, now buried, was discovered by the engineers of the enlargement of the Welland canal, according to Prof. Claypole (Can. Nat. Vol. ix. No. 4). When constructing No. 1 lock, at Port Dalhousie, it was found that at its northern end, there was an absence of hard rock which formed the foundation of its southern end. Rods more than 40 feet long were pushed into the slimy earth without meeting any hard rock bottom. This discovery will be noticed in the sequel.*

Basin of Lake Erie.—The exceedingly shallow basin of Lake Erie has its bottom as near a level plane as any terrestrial tract can be. Its mean depth, or even maxima and minima depths from its western end for more than 150 miles, scarcely varies from 12 or 13 fathoms for the greater portion of its width. The eastern 20 miles has also a bed no deeper than the western portion. Between these two portions of the lake the hydrography shows an area with twice this depth (the deepest sounding being 35 fathoms). This deepest portion skirts Long Point (the extremity, a modern peninsula of lacustrine origin), and has a somewhat transverse course. An area of less than 40 miles long has a depth of more than 20 fathoms. The deeper channel seems to turn around Long Point, and take a course towards Haldimand county, in our Canadian Province, somewhere west of Maitland. The outlet of the lake, in the direction of the Niagara river, has a rocky bottom (Corniferous limestone.)

The Dundas Valley and adjacent Cañons.—We may consider that the Dundas valley begins at the "bluff" east of the Hamilton reservoir, and extends westward, including the loca-

* See Report of Chief Engineer of Canadian Canals, 1880.

tion of the city of Hamilton and the Burlington bay, at least its western portion. With this definition, the width at the "Burlington heights" (an old lake terrace 108 feet above present level of the water) would be less than five miles. At a mile and half westward of the heights, the valley suddenly becomes narrowed (equally on both sides of its axis of direction, by the Niagara escarpment making two equal concave bends, on each side of the valley, whence the straight upper portion extends, the whole resembling the outline of a thistle and its stem), from which place it extends six miles westward to Copetown, on the northern side; and three and a half to Ancaster, on its southern side. The breadth between the limestone walls of this valley varies somewhat from two to two and a half miles. The summit angles of the limestone walls on both sides are decidedly sharp.

Dundas town is situated in this valley, its centre having a height of about 70 feet above Lake Ontario, but its sides rise in terraces or abrupt hills—many rounded and resembling *roches montounées*. On ascending the valley we find that between the escarpments are great ranges of parallel hills separated by deep gorges or glens, excavated in the drift by interglacial and modern streams. This rugged character continues until the summit of the Post Pliocene ridges have a height equal to that of the escarpment. As the gorges ascend towards the westward, they become smaller, until at some distance south-west of Copetown and Ancaster, the divide of the present system of drainage is reached. Some of these streams have cut through the drift, so that they have only an altitude above the lake (which is seven miles distant) of 240 feet, while the tops of the ridges immediately in the neighborhood are not much less than 400 feet high, though they themselves have been removed to a depth of about another hundred feet, for the drift has filled the upper portion of the valley to the height of 500 feet above Lake Ontario. Even to the very sources of the streams, the country resembles the rivers of our great North Western Territories (or those of the Western States), cutting their way through a deep drift at high altitudes, which is not underlaid by harder rocks, showing deep valleys rapidly increasing in size and depth, as they are cleaning out the soft material, and hurrying down to lower levels—a strong contrast to the features in most other portions of our Province.

On the southern side of the Dundas valley, a few unimportant

streams, mostly dry in summer, have worn back the limestone escarpment, over which they flow, to distances varying from a few yards to a few hundred, making glens at whose head in spring time some picturesque cascades can be seen. At Mount Albion, six miles east of Hamilton, there are two of these larger gorges, whose waters, after passing over picturesque falls, 70 feet high, and through glens several hundred yards in length, empty into the triangular valley noticed before. On the northern side of the Dundas valley, besides small gorges with their streams comparable to those on the south side, there are several of much larger dimensions; for example that at Waterdown, six miles north of Hamilton. Still larger is Glen Spencer which has a *cañon* half a mile long, 300 feet deep and between 200 and 300 yards wide at its mouth. At the head of this is Spencer falls, 135 feet high, and joining it laterally there is another *cañon*, with a considerable stream flowing from Webster's falls, which, however, is of less height than the other. The waters feeding these streams come from northward of the escarpment, and belong to a system of drainage different from those streams which flow down through the drift of the Dundas valley, and are of much greater length. At the foot of Spencer falls, the waters strike the upper portion of the Clinton shaly beds. The Falls are two feet deeper than twenty years ago. Yet the stream is small, and makes a pond below in the soft shales. But this difference in height does not represent the rate of wearing or recession of the precipice, but only the removal of a little *débris* at the base. That the stream is much smaller than formerly is plainly to be seen, for at present it has cut a narrow channel, from ten to fifteen yards in width, above the falls, and from four to six feet deep on one side of the more ancient valley, which is about 50 yards wide and 30 feet deep, excavated in the Niagara dolomites.

The surface of the escarpment on both sides of Glens Spencer and Webster presents a peculiar aspect. That on the north-eastern side has a maximum height of 520 feet above the lake. On the same side, a section, made longitudinally, shows several broad shallow glens nearly a hundred feet deep crossing it and entering Glen Spencer. The surface of the rocks is glaciated, but not parallel with the direction of the channels. On the south-western side of the same *cañon*, we find that a portion of the thin beds of Upper Niagara limestone have been removed. This absence is not general, for it soon regains its average height of about 500 feet.

Dundas Marsh.—The eastern end of the Dundas valley contains a large swamp, nearly three miles long, with a breadth of about three-fourths of a mile, known in the early settlement of the country by the name of Coote's Paradise.

This marsh was formerly connected by a small rivulet with Burlington bay, but this was subsequently closed by the G. W. Railway, when the cutting of Desjardin's canal through Burlington heights was completed. Into this marsh all the drainage of the Dundas valley is deposited, causing it to fill up at the rate of one-tenth of a foot per annum.

Burlington Heights.—Across the eastern end of the Dundas swamp and some of its branches, are the Burlington heights, varying from a few hundred yards to nearly a quarter of a mile in width, and over 100 feet in height, which have been an old beach, at a time when the lake level was at the same elevation, for we find that a lake beach extends along the flanks of the escarpment, both eastward and northward for a considerable distance at the same level. This is mentioned here as forming a most conspicuous terrace, and as changing the physical character of the western extremity of Burlington bay, and the outlet of the Dundas valley. Various terraces and beaches are found, both at lower levels, and also fragments at higher altitudes along the side of the "mountain," until some attain a height of 500 feet above Lake Ontario.

The Grand River Valley.—The Grand river of Ontario rises in the County of Grey, not more than twenty-five miles from Georgian bay. Thence it flows southward, and at Elora the river assumes a conspicuous feature. Here it cuts through the Guelph dolomites to a depth of about 80 feet and forms a *cañon* about 100 feet in width with vertical walls. At this place it is joined by a rivulet from the west, which has formed a tributary *cañon* similar to that of the Grand river itself.

The country in this region is so flat that it appears as a level plain. Farther southward the river winds over a broader bed, and at Galt the present river valley occupies a portion of a broad depression in a country indicating a former and much more extensive valley. In fact, the old river valley existed in Preglacial times, for the present stream has re-excavated only a part of its old bed at Galt, leaving on the flanks of one of its banks (both of which are) composed of Guelph dolomites, a deposit of Post Tertiary drift, in the form of a bed of large rounded boulders

mostly of Laurentian gneisses. The country for four miles south of Galt is of similar character, forming a broad valley, in which the present river flows. At this distance from Galt the river takes a turn to the south-westward; but at the same place, the old valley appears to pass in a nearly direct line with the course of the present bed (before the modern turn is made to the westward). As this portion of the valley now entered has not to any extent been cleaned out by modern streams, it forms a broad shallow depression in the country extending for a few miles in width. Yet, it is often occupied with hills composed of stratified coarse gravel belonging to that belt, which extends from Owen Sound to the county of Brant, and called by the Canadian Geological Survey "Artemesia gravel."

It is through a portion of this valley that the Fairchild's creek flows. Many streams derive their supplies of water from the Beverly swamps, and feed the Lindsay creek, which empties over Webster falls and flows down Glen Spencer through the Dundas valley to Lake Ontario.

The G. W. Railway at four miles south of Galt enters the Grand river valley and continues in it or its branches as far as Harrisburg, though the deeper depression is near St. George (a short distance west of Harrisburg). After leaving what I consider its more ancient bed, south of Galt (unless the country between the present bed and Fairchild's creek was an island), the Grand river flows southward to Paris and Brantford, having a deep broad valley. At Paris, Nith's creek enters the Grand river from the west, and has a valley almost comparable in size with that of the latter at this town. At Paris, the Grand river cuts through the plaster-bearing Onondaga formation. Similar rocks appear at various places along the river, where the stream has cleaned out a portion of one side or other of its ancient valley.

Between the elevated plateau (of nearly 100 feet close to Lake Ontario) south of Brantford and that rolling country of equal height near Harrisburg, the alluvial-covered plain of from 400 to 460 feet above lake Ontario, more than ten miles wide, may be considered as a portion of an ancient enlargement of the great river basin.

At the Great Western Railway crossing east of Paris, the bed of the river has an altitude of 495 feet above Lake Ontario, whilst at Brantford it is 398 feet above the same datum. From Brantford the river winds through a broad valley, with a general

easterly direction to Seneca, where the immediate bed is about a quarter of a mile wide, flowing near the southern side of a valley, more than two miles wide.

At Seneca the bed of the present river course is 365 feet above Lake Ontario, or only 37 feet above Lake Erie. Eastward of Seneca, the river continues to have its broad valley as far as Cayuga, where the hard bed of the river is below the surface of Lake Erie.

From Seneca to Cayuga the direction of the river is nearly south, but at the latter place it abruptly turns nearly to the eastward, and in a short distance it passes to a flatter country and flows over Corniferous limestone. After a sluggish flow, it enters Lake Erie (passing through a marshy country) at Port Maitland, more than fifteen miles in a direct line from Cayuga.

The Grand river valley (75 feet deep) is more than two miles in width and bounded by lateral elevations of 440 feet above Lake Ontario, or 113 feet above Lake Erie; and farther by boundaries; on both sides, of 160 feet above the latter lake.

At Dunville, a few miles from the mouth of the river, piles were driven to a considerable depth without reaching hard rock. The margins of the valley are small, composed of either the more or less shaly Onondaga rocks, or Corniferous limestone. In the meanderings of the river from one side of the valley to the other, it occasionally crosses spurs of earthy Onondaga limestones, but the character is not such as to preclude the possibility of an adjacent buried river channel. At most, all the waters that could come down the Grand river, even with an increased pitch of the country, and a larger precipitation of moisture would scarcely be able to more than excavate its present bed. The country on either one side of the river or other is remarkably broken within the limits of the valley, but beyond it is equally remarkable for its level surface. This broad peculiar valley bears a strong contrast to that of the upper portion of its course (as at Elora) where the *cañon* could have easily been excavated by the present stream if sufficient time were given.

Returning to the valley of Fairchild's creek, we find the stream principally flowing in the former bed of the Grand river, abandoned a few miles below Galt since the Ice Age. This creek crosses the Great Western Railway at a level of fifteen feet below the crossing of the Grand river, at a few miles to the westward. Again, the Fairchild's creek crosses the Brantford and Harris-

burg Railway at an altitude of 397 feet above Lake Ontario, or a little below that of the Grand river at Brantford, although it empties into it a few miles east of the city just named. Fairchild's creek is now of moderate size meandering through the drift for a width of two miles. This drift is stratified clay.

Country between the Grand River and Dundas Valleys.—The watershed between these two present drainage systems is at only a short distance south-west of Copetown, and the distance in a direction from the Fairchild's to the Dundas side of this divide is less than seven miles, with an average altitude of less than 480 feet. The highest point that I have levelled is 492 feet above Lake Ontario. On receding westward from the divide, the country gradually descends to the Fairchild's creek. The region between the divide and the Grand river is traversed from north-west to south-east by a considerable number of streams, all with relatively large valleys, cut in the drift, since the present system of drainage was inaugurated in interglacial or modern times.

The country from Jerseyville (about 465 feet above lake) slopes gradually to the Grand river, from six to eight miles distant to the southward.

On examination, it may be seen that the country is too high to permit the Fairchild's creek or Grand river, as they are at present situated, to flow over the height of land into the upper portion of the Dundas valley. As referred to before, the Niagara limestone forming the summit of the escarpment at Ancaster and eastward has a height of about 500 feet. These beds dip at only about 25 feet in a mile (to about 20 degrees west of south) and are not generally covered by a great thickness of drift, but in many places are exposed on or near the surface. Westward of Ancaster these limestones are nowhere to be found, but the country is only covered with drift. At a short distance west of this village, we find streams flowing north-easterly and easterly with very deep valleys in the drift, indicating the absence of the floor of limestone to a depth of over 220 feet below the surface of the escarpment. On going westward we find that the streams have not cut to an equal depth, but are still running deeply through drift.

On reaching the divide west of Ancaster village, we find that the valleys, excavated out of the drift belonging to both the Dundas valley and Grand river drainage, inosculate at an elevation

of about 400 feet above Lake Ontario, thus showing the former connection of the basins more than 100 feet below the rocky flows which surround them. Even in this depressed area wells are known to reach 60 feet in the drift without meeting with solid rock.

On the northern side of the Dundas valley the escarpment after reaching Copetown is buried by the drift. Although the line of buried cliffs recedes somewhat to the northward of the Great Western Railway, yet there are occasional exposures, as at Troy and other places in Beverly and Flamboro, where the underlying limestones come to the surface. At Harrisburg the limestones are known to be absent for a depth of more than 72 feet, as shown in a deep well in the drift.

In the town of Paris one well came upon hard rock at 10 feet below the surface, whilst another at 100 feet in depth, reached no farther than boulder clay. This last well must have been in a buried channel of Nith's creek, as outcrops of gypsum bearing beds of the Onondaga formation frequently occur near the summit of the hills. From what has just been written, it is easily seen that the Niagara limestones are absent from a more or less horizontal floor (which is over 500 feet above the lake, on both the northern and southern sides of the Dundas valley) which continues from Dundas westward to near Harrisburg, where it meets a portion of the Grand river valley. But almost immediately west of Ancaster we find streams running northward at right angles to the escarpment, and cutting through drift to the depth of almost hundreds of feet. In fact, if we draw a line from Dundas to northward of Harrisburg (a mile or two), and another from Ancaster southward to the Grand river, we have two limits of a region where the limestone floor has been cut away from an otherwise generally level region. The southern side of this area is the southern margin of the Grand river valley, between Seneca and Brantford, and the western boundary is composed of Onondaga rocks east of Paris (which perhaps forms an island of rocks buried more or less in drift).

Additional proofs may be cited. About a mile south of Copetown a well was sunk to the depth of 100 feet before water was obtained. At two miles south-east of the same village there is a small pond only 240 feet above Lake Ontario, or more than 260 feet below the neighboring escarpment. This is in drift. Again, at a mile north of Jerseyville, the country has a height of 465 feet,

with a well in the surface soil to a depth of 40 feet. A small rivulet flows in a valley a few hundred yards south of the last named well which has a bed 435 feet above the lake. At about a mile west of Jerseyville, the altitude is 468 feet with a well 52 feet deep. Again, at about two miles west of the same village, near the county line, the altitude is 460 feet, with a well 57 feet deep. About a mile north of the last named station is a ravine 436 feet with the adjacent hills forty feet higher, and rising in a mile or two to about 500 feet. All these wells are in the drift. From exposures near Ancaster, it appears that the unstratified drift has not an altitude of 400 feet. And as we know that some of these superficial beds are stratified clay, and over most of the country just described not a boulder is to be seen, neither on the surface nor in the material taken from the greater portions of the wells, it is probable that the water is only obtained on nearing the more porous boulder clay below. It has also been noticed that two wells, at least, are 100 feet deep before reaching water, therefore we may fairly place this as about the inferior limit of stratified superficial clays. It will be seen that westward of the meridian of Ancaster there is an area of over 100 square miles, where the Niagara floor is known to be removed everywhere to a depth of 100 feet, and in its eastern portion to more than 260 feet, and still nearer Lake Ontario to a measured depth of more than 200 feet below its waters.

III.—THE BURIED RIVER CHANNEL IN THE DUNDAS VALLEY AND ITS EXTENSIONS.

That the Dundas valley is that of an ancient river valley now buried to a great depth with the *débris* produced in the Ice Age, becomes apparent on a careful study of the region. However, until a key was discovered the mystery of its origin was found to be very obscure. My own labors at studying this region may fairly be stated as the first systematic attempts at the solution of the present configuration of the western end of Lake Ontario and the adjacent valley. Assertions have been made that it was scooped out by a glacier, but this wild hypothesis was only a statement made withont any regard to facts.

From the description of the topography, given in section II, of this paper, it will be seen that the apparent length of the rock-bound valley is six miles with a width of over two miles; then it widens suddenly to four miles (with concave

curves on both sides) after which it gradually increases in width as it opens into Lake Ontario. The direction of the axis of the valley is about N. 70° E. The summit edges of the rock-walls on both sides are sharply angular and not rounded or truncated. This angularity is not due to frost action since the Ice Age, to any extent, as is shown by the character of the talus. The rocks of the summit are frequently covered with ice markings, but I am not aware of any locality where they have been observed as being parallel with the true direction of the valley, but on all sides one can observe them (sometimes at only small angles of less than 30 degrees) making conspicuous angles with its axis. One exception may be made to this statement. On a projecting ledge of Clinton limestone, at Russel's quarry, near Hamilton, at a height of 254 feet above the lake, and 134 feet below the summit of the "mountain," after the removal of some talus, I observed that the surface was polished, but with scratches so faint that they could scarcely be compared with those of fine sandpaper on wood; and the direction, if determinable, was parallel with the overhanging escarpment. There are many tributary *cañons*, which are evidently of greater antiquity than the Ice Age, which could not have excavated by the present streams, and are at all sorts of directions compared with the striated surface of the country.

The topography of the lower lake regions precludes the idea of a glacier flowing down the valley to the north-eastward. Again, as the direction of the ice was towards the southwest, the waters from the melting glaciers could scarcely flow up an escarpment many hundreds of feet in height. Even if the Niagara escarpment did not exist elsewhere, the non-parallelism of the striæ, and edges of the escarpment with their angular summits, is sufficient to prove the non-glacial origin of the valley in the hard limestone rocks. Moreover, at the eastern end of the narrower portion of the valley, there are two concave curves facing the lake, which of necessity would have been removed if such a gigantic grinding agent had been moving up the valley.

This glacier-origin of the valley being an absolutely untenable hypothesis, I sought for some fluviatile agent capable of effecting the present configuration of the region. At the time, no idea occurred that even the great valley of the present is only a miserable remnant of one of gigantic proportions obscured by hundreds of feet of drift. The question arose, could Lake Erie have ever

emptied by this valley? This suggestion did not hold its ground for any length of time, because the present levels are all too high. Near Galt, the traces of the true origin first presented themselves. A branch of the Great Western Railway extends from Galt southward for about four miles in the valley of the Grand river, after which, without making any important ascent, it passes into the broad older valley, described above as that in which Fairchild's creek now flows. After a careful examination of the region, and of the railway levels, I came to the conclusion that this was an old buried valley. It then became apparent that if the Grand river had occupied the site of the Fairchilds's creek, that the latter probably flowed down the Dundas valley, and that the Grand river, being one of the largest of the rivers of Ontario, might have been a sufficent cause for the great excavation at the western end of Lake Ontario. Having procured all the levels that bore on the subject which were available, it became necessary to connect several places myself by instrumental measurements, which work was accomplished with the aid of Prof. Wilkins. As the whole floor of Niagara limestones is absent, as has previously been shown, the proof that the ancient Grand river flowed down the Dundas valley was completed, and of this discovery there was published a local notice in August, 1880. Significant and interesting as this fact was, relative to the change of systems in our Canadian drainage, a still more important issue was involved. When taking the levels between the Dundas valley (modern) and the Grand river, it was found that the whole calcareous floor was removed from a basin several miles in width, and that all the wells were sunk to a considerable depth in the drift before water could be obtained. On glancing at the map it will be seen that the Grand river from Brantford to Seneca meanders through a broad course, which in its ancient basin is several miles in width, but that from Seneca the valley is narrower, and the course of the stream more direct, as far as Cayuga. At Seneca the valley is two miles wide, and seventy-five feet deep. Also the bed of the Grand river at Seneca is in drift which is only 37 feet above the lake into which it now empties, as has been pointed out in the section.

Having observed the connection between the Dundas valley, Grand river and Lake Erie, it dawned on me that I had established the knowledge of a channel having a very important bearing on the surface geology of the lake region. It now be-

came apparent that Lake Erie had flowed through the Grand river valley reversed, to a point west or north-west of Seneca, and thence by the Dundas valley into Lake Ontario; also that the upper waters of the Grand river, previously discovered as passing down the Dundas valley, were really tributary to the outlet of Lake Erie, and joined it somewhere south of Harrisburg; and that the basin between the Brantford (and the Grand river of to-day) and the Great Western Railway, at Copetown, formed an expanded lakelet along the course of the ancient outlet of Lake Erie, scooped out of the softer rocks of the Onondaga formation before noticed. As the waters excavated a bed in a deeper channel, of course this lakelet would become an expanded and depressed valley, such as we often see amongst the hills of drift,

Fig. 2.

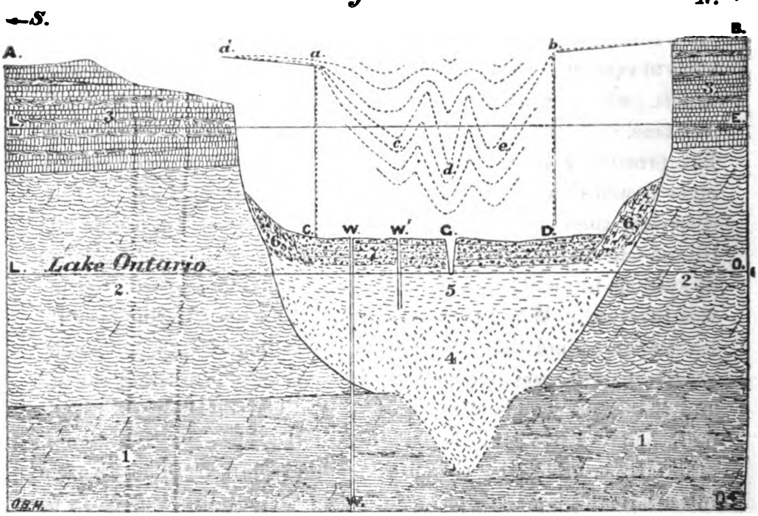


Fig. 2.—1. Hudson River formation; 2. Medina shales; 3. Niagara and Clinton dolomites with some shales. A, C, D, B, modern valley at meridian of Burlington heights; a, C, D, b, modern valley at meridian of Dundas; a, c, d, e, b, sections across, deeply excavated in beds of streams in western part of the Dundas valley; 4. Boulder clay filling ancient valley; 5. Erie clay; 6. Talus from sides of escarpment; 7. Old beach, 108 feet above lake at Burlington Heights; G, Desjardin's canal leading from Dundas marsh to Burlington bay; W, W, well at Royal Hotel, Hamilton; W′, another well at Dundas; L, O, level of Lake Ontario; L, E, level of Lake Erie. Horizontal scale, 2 miles to an inch; vertical scale, 400 feet to an inch.

at a short distance westward of Dundas. Possibly the Grand river divided and flowed around an island, the western side of which is occupied now by the town of Paris. At any rate, Neith's creek, at that town, formed a large tributary to the river then flowing down to Lake Ontario.

From a careful study of the broad valley of the lower portion of the Grand river, it becomes apparent that it was a portion of the outlet of Lake Erie, which passing to the region of Seneca village, turned towards the Dundas valley, although the present river exposes shaly Onondaga rocks, occasionally as it approaches the margins of the old valley.

Again Mr. Carll has shown that the Alleghany drainage passed near Dunkirk into the Erie basin at a place just opposite to its outlet, as indicated by the present writer.

Much of the Dundas valley is underlaid by stratified Erie clay, which is known to extend to a depth of 60 feet below the surface of Lake Ontario, according to Dr. Robert Bell. In the upper part of the valley, streams have exposed some deposits of unstratified clay filled with angular shingle, derived from the thin beds of limestone forming the upper portion of the Niagara formation. In the eastern portion of the valley, the Erie clay is overlaid unconformably by brown Saugeen clay or loam (stratified). In the upper portions of the valley the hills are capped by brown clays or sands. But along some of the hillsides excavated so deeply in the drift, we find old beaches resting unconformably on boulder clay.

Near the centre of the city of Hamilton, in the wider portion of the Dundas valley, a well was sunk to the depth of over 1000 feet. This well revealed a most interesting fact. Though known to me several years ago, I did not apply it until recently to its true bearing, since discovering the origin of the Dundas valley. Mr. J. M. Williams sunk this well, at the Royal Hotel, in Hamilton. He told me several years ago that he had to sink through 290 feet of boulders, before coming to hard rock, thus causing the outlay of a large sum of money in excess of his calculations. Unfortunately this well-record has been lost by fire. At that time the fact was so fresh in his memory (improved by the extraordinary cost of the well) that his statement could be relied on, being experienced in well-borings. The mouth of this well is 63 feet above Lake Ontario, and therefore the hard rocks are absent for a depth of 227 feet below the lake surface. See section, Fig. 2.

As the valley is five miles wide at this place, and as the well is only about one mile distant from its southern side, it becomes apparent that the valley in the centre must have been much deeper. Moreover, if we produce the southern side of that portion of the valley, which is over two miles wide, we find that the well is less than a quarter of a mile away from it. Now if we connect the top of the Medina shales (240 feet above Lake Ontario) with the base of the drift in the well, and produce it to the centre of the valley, it wonld indicate a central depth of over 500 feet. At the base of the drift there are nearly fifty feet of Medina shales, below which are the Hudson River rocks (more or less calcareous and arenaceous, mixed with the shales). This harder formation along the bed of a river would be less extensively removed by aqueous action than the overlying Medina shales, especially as the pitch of the waters would be much lessened. This graphic method of calculation seems as perfectly admissible here as it does in determining other constants of nature. However, I have placed the estimated depth in the section at about 70 fathoms below the lake surface, which depth is perfectly compatible with the soundings of the lake at no very great distance to the eastward. Even this depth gives only very gentle slopes from the sides of the river valley. It should be remarked that Burlington bay is excavated from stratified clays in places to a depth of 78 feet. But this water is silting up comparatively quickly.

Now we have seen that the deep excavation in the Dundas valley and westward is cut through more than 250 feet of Niagara and Clinton rocks, mostly limestone, and to a depth in the Medina shales, so that the total known depth of the *cañon* is 743 feet, but with a calculated depth in the middle of the channel of about 1000 feet. This depth for a *cañon* is not extraordinary for Eastern America. In Tennessee there are river valleys excavated to a depth of 1600 feet. And in Pennsylvania Mr. Carll reports others to be equally deep.

Again, this Preglacial river explains the cause of the present topography of the western end of Lake Ontario. The drainage by this river swept past the foot of the submerged escarpment of Lake Ontario described in preceding pages, until it reached the meridian of Oswego.

With such an outlet, and with the ancient Grand river valley buried by greater or less depth, we have an easy solution

to the problem of the drainage of Lake Erie. Moreover the present barrier between the lakes may have quite probably been increased by local elevation of the land as we find the indications pointing to the Dundas valley being along the axis of an anticlinal of less than one degree of dip.

Attention has been called in this paper to the deepest portion of Lake Erie being southward of Haldimand county, and about the end of Long Point, and extending transversely towards the Pennsylvania shore.

So far, our remarks have been applied to Canada. If we turn towards the American shore, we will see that the observations made there go very strongly in support of what has been written.

Several years since Dr. Newberry, Mr. Gilbert, and others, called attention to the deeply buried valleys of the Cuyahoga, Chagrin, Grand, Maumee and other rivers in Ohio, which emptied into Lake Erie much below their present levels. The Cuyahoga has its channel buried to a depth of 228 feet below the surface of Lake Erie of our time, whilst the deepest water in the neighboring portion of the lake is less than a hundred feet.

In Report III, of the Pennsylvania Geological Survey, issued in November, 1880, Mr. John F. Carll published excellent maps of the Preglacial drainage of that State and the neighboring portions of the adjoining States. This report on the Preglacial rivers is the result of five years' labors in the oil regions, and many of Mr. Carll's results have been derived from the facts made known by the borings for the mineral oil.

Besides calling attention to the very deep valleys of erosion amongst the mountains, Mr. Carll has shown that in the oil regions the river valleys are frequently filled with drift to a depth of from 200 to 450 feet. In fact nearly all the present rivers flow over beds deeply filled with drift. The map of the Preglacial drainage shows that the upper waters of the Alleghany emptied by the Cassadaga river, reversed, into Lake Erie, near Dunkirk, and had for tributaries many other streams now flowing southward; for example the Conewango. These streams drained an area of 4000 miles, which now sends its surplus waters to the Ohio river. The French and other rivers now emptying southward from the Conneaut basin, emptied in Preglacial times into Lake Erie, westward of Erie city. Again, the Chenango, Connoquenessing, Mahoning and other tributaries of the Beaver river (itself now emptying into the Ohio) flowed northward, by

the Mahoning river, reversed, into the state of Ohio, to near the sources of the Grand and Cuyahoga rivers. Hence Mr. Carll did not continue its course, on the map, but from the study of the levels and character of the country, as described by the Geological Survey of Ohio, I have connected it with the Grand river of Ohio, as represented on my map. In addition to this drainage I have pointed out the probability* that the Mahoning and upper Ohio, with the Beaver (reserved), Mahoning (reserved) and Grand (of Ohio) rivers formed a nearly straight valley, from the western side of the mountains of Virginia to Lake Erie.

Thus we find three large areas now flowing southward formerly emptying into Lake Erie basin.

The deepest portion of Lake Erie is between these ancient river mouths and the ancient *débouchement* of the Erie drainage by the Grand river of Ontario, as described in these pages.

Thus we have shown a consecutive system of drainage of the former waters of the buried channels into Lake Ontario, and thence running along the foot of the submerged escarpment of the latter lake to its eastern end, receiving the Genesse and other large rivers along its course.

Not only is the Dundas valley a deeply buried channel, but nearly all the streams that enter Lake Ontario are flowing over more or less deeply buried channels.

Origin of the Lower Great Lakes.

All of the chain of Great Lakes of North America are excavated principally out of the more or less shaly almost horizontal rocks of the various basins. They are all valleys of erosion (excepting perhaps, a portion of Lake Superior.) The erosive action of the atmospheric agencies would tend to wear the country into undulating basins,—for only such are the bottoms of the great Lakes. It is true that slight geological undulations may have determined the position of the lake-basins. The basins of Lakes Michigan, Huron and Ontario, especially, are traversed by long sub-lacustrine valleys resembling those of large rivers, and bounded by escarpments, which rise abruptly several hundred feet high. The description of the lake beds—the probable Preglacial outlets of Lakes Superior and Michigan (discharging their waters to the Mississippi valley); the outlet of Lake Huron

* See Proc. Am. Phil. Soc. XIX, 108.

(at least during a portion of its history) across the southwestern counties of the Province of Ontario, and entering the Erie basin somewhere between Vienna and Port Stanley; as well as a former outlet of Lake Erie into Lake Ontario, have been discussed somewhat fully in my paper published in the Transactions of the American Philosophical Society, already referred to. In order to keep nearer to the present subject of study, I will confine my remarks on the "Origin of the Lakes," to that of Lake Ontario, for the other lakes give corresponding testimony.

Dr. Newberry prophesied that an outlet for Lake Erie into Lake Ontario would be discovered near the Welland canal. This outlet in an unexpected position I have discovered, and in a position which explains more perfectly the cause of the topography of Lake Ontario than any that could have been discovered forty miles to the eastward.

When was the advent of such a drainage system for this continent? Some of our American friends, who have advocated the sub-aerial and fluviatile origin of the lakes, have placed it back to the Devonian Age. About the commencement we know nothing. It would be safer to place it after the Palæozoic time, for probably, some portions of the Province of Ontario were covered with carboniferous deposits, as well as Michigan and Ohio, which have subsequently been removed by denudation.

Excavation of Lake Basins. Having seen the course of the Preglacial drainage, let us ask how the broad lake troughs could be excavated. Let us look at Lake Ontario.

The river coming down the Dundas valley flowed originally near the out-crop of the Niagara limestones, elevated by geological causes long ago. The direction of the stream was parallel to its trend. On the one side were the soft Cambro-Silurian shales, geographically higher, geologically lower; on the other (southern) side, the Niagara limestones, beneath which were the soft Medina shales until these were worn away in part. As the shaly rocks were removed and the limestones were undermined, the NIAGARA ESCARPMENT was produced. How far these limestones have receded towards the present face and summit of the slope, is a question yet to be decided. As the waters sunk to a lower level a second escarpment was produced (the one noticed at Port Dalhousie, at the present lake level). Afterwards the Hudson River shales (with some hard rocks) were pierced whilst yet there were capping Medina shales, forming the surface of the country between the river and the limestone escarpment.

All this presupposes the continent at a higher level (at least 600 feet). During some portion of the tertiary times, at least the eastern portion of the continent must have stood a thousand or twelve hundred feet higher than at present, as indicated by the soundings in the St. Lawrence river (near the mouth of the Saguenay), in the New York Harbour and off the mouth of the Chesapeake Bay.

The rate at which the upper lakes was excavated would depend partly upon the rate of the excavation of the Dundas valley and its extensions through the limestone, at first by a slow abrasion, and the solution of the carbonate of lime by the carbonic acid held in the water, and afterwards by the undermining of the hard rocks on the removal of the Medina shales.

(*To be continued in our next.*)

NATURAL HISTORY SOCIETY.

PROCEEDINGS FOR SESSION 1881–82.

The fifth meeting was held on Monday evening, Feb. 27th—the President in the chair.

On motion of Mr. Marler it was resolved that Dr. Johnson and the Recording Secretary be a Committee to draw up a petition for presentation to the Dominion Government for a general increase of grants to scientific institutions in Canada.

The Cabinet-keeper exhibited seven mounted birds, recent additions to the museum, viz.: *Alcyon Australis*, *Nestor producius*, *Carpophasa Novæ Zealandiæ*, *Porphiris speciosus* (2 specimens), and *Anthochaera coriculata*.

The gentlemen proposed for membership at last meeting were elected. The following gentlemen were proposed for ordinary membership:

Charles Gibb.	W. J. Buchanan.
A. E. Duncan.	Alex. Ewan.
C. F. Smithers.	Harington Bird.

Major Latour proposed as an honorary member M. le Comte de Sesmaisons, Consul-General of France.

Mr. Chas. Robb, C. E., then read an interesting paper on "The Geology and Natural History of the Island of St. Ignace, Lake Superior." The part of this paper concerning the geology of the locality in question appeared in Vol. X., No. III of the "Naturalist."

Principal Dawson then exhibited some interesting post-pliocene fossils, and gave a brief review of a recent essay by Dr. A. J. Von Wœickoff on the Glacial Period. This review will be found in full at page 181 in preceding number of this Journal.

The sixth meeting was held on 27th March, the President in the chair. After reading of minutes, Dr. Edwards and Mr. Muir were authorised to arrange for meetings of the Microscopic Club in the Society's Rooms.

The gentlemen proposed at last meeting were duly elected members of the Society.

Dr. Edwards then addressed the meeting on the "Cornwall Water Supply," giving results of his analyses of a number of samples of water from various sources in and around the town of Cornwall.

The Recording Secretary then read an abstract of a paper on "The Surface Geology of the Baie de Chaleurs Region" by Mr. R. Chalmers.

The paper appears in full in this number of the "Naturalist."

The President directed the attention of members to a large specimen of fresh-water sponge found by R. J. Fowler, Esq., in a mill dam at Scotswood, P. Q., and presented by him to the Society.

The seventh meeting was held on April 24th, the President in the chair.

It was decided to grant the American Association for the Promotion of Agricultural Science the use of the Society's Rooms for their meetings, to be held on the 21st and 22nd August.

Mr. W. F. Ferrier was proposed for ordinary membership.

Recent donations to the Museum, consisting of mineralogical specimens from W. F. Ferrier, Esq., and a Brazilian monkey from Mr. Papineau, were exhibited.

Mr. J. T. Donald then presented a few "Notes on Titanic Iron." He stated he had examined a large deposit of this substance in the Laurentian country, north of St. Jerome, in the parish of St. Agathe des Monts. The ore rested upon Labradorite rocks. It contained 27.6 per cent. titanic acid and 41.92 per cent. metallic iron.

The President exhibited a remarkable inscription, consisting of the letters J.C., M.J.F., with certain religious emblems, which had been engraved on the bark of a beech tree and overgrown by a great number of annual layers of wood. It had been observed in splitting the tree for firewood. The specimen was the property of Mr. A. Oswald, of Belle Rivière, Two Mountains, and had been sent by him for exhibition at the request of Mr. J. R. Dougall. In a botanical point of view the specimen is a rare and remarkable example of the manner in which wounds on the bark of an exogenous tree may be grown over and concealed. It also showed the possibility of an inscription being perfectly preserved in the interior of a tree when entirely concealed by subsequent layers of wood and bark.

The President called upon Dr. Edwards to explain to the meeting the general forms of microscopes and their illumination, which that gentleman did. Dr. Edwards also stated that the

object of asking the members of the Microscopic Club to attend the meeting was to see what instruments there were in Montreal, because there would be a Microscopic section in the American Association meetings.

The remainder of the evening was spent in inspecting with the microscopes Natural History objects of different kinds.

ANNUAL MEETING.

The annual meeting was held on the evening of May 18th, the President in the chair.

THE PRESIDENT'S ANNUAL ADDRESS.

The President, Principal Dawson, first delivered his annual address to the members of the Society. He said :—

The present session, I believe, completes the half century since the incorporation of this Society, though its actual foundation dates from the year 1827. At the annual meeting before last, Major Latour gave you an interesting account of its various exertions within that time for the advancement of Canadian science, and which have not only steadily promoted our national growth in this respect, but have led to the institution of great public departments which may be said to have outgrown the Society itself. At the last meeting our attention was directed to the propriety of extending to the American Association for the Advancement of Science an invitation to hold a second meeting in Montreal after the lapse of twenty-five years. In this we have been happily successful. The invitation tendered by this Society has been unanimously and cordially accepted, and we hope on the 23rd of August again to welcome the *élite* of the scientific men of the United States and Canada to the hospitalities of our city. A large and influential local committee has already been organized, and has commenced its labours with that zeal and public spirit which ever characterizes the action of the citizens of Montreal in such matters. The meeting held here in 1857 was one of the most successful up to that time, and it is hoped that the meeting of 1882 may have a similar character. We must remember, however, that the American Association has grown to a much larger body than it was in 1857, and that correspondingly large demands will be made upon us, while correspondingly large benefits may be expected, more especially in

the stimulus which will be given to science and scientific arts and industries. In connection with the latter result, not only will there be discussion of the latest results and improvements in the mechanical and chemical arts that depend upon science, but there will be meetings at the same time of the Society for Promoting Agricultural Science and of the American Forestry Association. In prospect of the approaching meeting we are also gratified with the fact that several eminent scientific men from Great Britain and the continent of Europe have responded favourably to the invitation sent by Dr. Sterry Hunt, the chairman of the Local Committee, and we hope that the presence of numerous savants from abroad will be a characteristic feature of the meeting. Montreal is, I think, to be congratulated on the prospect of another meeting here of the great Scientific Congress of this continent. Those who remember the meeting of 1857 know that benefits flowed from it to this city, the results of which still remain, and I trust that those of the approaching meeting will be on a still greater scale.

The session which closes to-night, whether we reckon it as the fiftieth or the fifty-third, may be characterised as a quiet and uneventful one. We have sensibly felt the removal of many of our most active members, caused by the transference of the officers of the Geological Survey to Ottawa. On the other hand we have had an unusual accession of members from the city, and it is hoped that this will not only enlarge the basis of support of the Society, but that some of our new members will contribute original work to our meetings. In connection with this it should be the study of the Council in the next session to endeavour to give added interest to the monthly meetings, so as to bring out a larger attendance of members and to create more lively discussion.

The papers read in the past session may be arranged under the heads of Chemistry, Geology and Natural History.

In Chemistry we have had communications from Dr. Baker Edwards and Mr. Donald on several practical subjects, more especially on analysis of waters used for household purposes, on certain resins imported into Montreal for the manufacture of varnishes, and on the composition of those titaniferous products which are associated with the Upper Laurentian Rocks.

In Geology the most important contributions were that on the recent remarkable discoveries of fossil fishes in the Devonian

rocks in the Baie de Chaleur by Mr. Whiteaves, that by Mr. Charles Robb on the geology of the Island of St. Ignace in Lake Superior, and that of Mr. H. M. Ami on the fossils of the Utica Slate. There were also additional facts and conclusions respecting the Post-pliocene formations brought forward by Mr. Chalmers and by the writer.

In Zoology we had an interesting contribution from Dr. Osler, in which he noticed three species of fresh water *Polyzoa* which have been recognized in the Province of Quebec. Under this head we may also place the notice at one of our meetings of the specimen of a whale exhibited in the city, and which appears to be *Balœnoptera musculus* a well known species, though one we rarely have so excellent an oportunity to inspect. We may also notice here specimens of larvæ and of animal preparations exhibited to us by Mr. Muir and other friends in the evening devoted to microscopic work.

Botany has scarcely appeared this session at our meetings; and for this reason I will close with a notice of the remarkable inscription preserved in the interior of a beech tree and exhibited to the Society by Mr. W. Oswald, jr., of Mill Farm, Belle Rivière. The inscription which consists of religious initials and emblems, enclosed in an ornamental border, has been made on the bark of a beech tree about four inches in diameter. The tree had subsequently grown to the diameter of more than two feet, and had covered the inscription with 160 rings of growth, a fact ascertained through the kindness of Mr. Oswald by sawing off a slice of the trunk. Yet the inscription was perfectly perserved, and was recovered in all its integrity when the tree was cut up for cordwood. Many objects buried in exogenous trees by their annual growth have been obtained in this and other countries; but this is a very rare instance of the perfect preservation in the inner layer of an old tree of an inscription made on the bark, and its recovery after the lapse of more than a century and a half. The forests of the world must contain many strange records of this kind, though they are brought to light only by very rare accidents.

In conclusion, the Society is to be congratulated on the improvements made in its collections and building in the past year, and I trust that with God's blessing its second half century may be found, when its history comes to be written by some future President, even more successful and useful than that which has passed away.

Mr. G. L. Marler then read the

REPORT OF CHAIRMAN OF COUNCIL.

As chairman of Council it is my duty to report that during the session now closing your Society has received the large addition of 125 members. The usual course of Sommerville Lectures, six in number, was delivered to large and appreciative audiences.

The Museum was open to the public each evening for one hour before the commencement of the lecture. It is estimated that not less than 2000 persons visited the Museum on these evenings.

The subjects of the lectures with the names of the lecturers were:

1882.

Feb. 2nd. Mountains and Valleys. Principal Dawson, C.M.G., F.R.S.

Feb. 9th. The Lungs and Air Passages in relation to Health and Disease. T. Wesley Mills, M.D.

Feb. 16th. Edible Fruits, their Composition, Preservation, and Causes of Decay. J. T. Donald, B.A.

Feb. 23rd. The Microscope and its Revelations. J. Stevenson Brown, Esq., assisted by Wm. Muir, Esq., with his Oxyhydrogen Microscope.

March 2d. Alcohol and its Physiological Effects. F. Buller, M.D.

March 9th. Notes on a Recent Trip to Europe. T. Sterry Hunt, LL.D., F.R.S.

The thanks of the Society are due to the gentlemen who delivered these lectures which were eminently successful, the lecture hall on each occasion being more than filled.

Your Council has also to report that an invitation to the American Association for the Advancement of Science was forwarded by a deputation of your Society which was cordially received and the invitation accepted. The citizens of Montreal were then called together in your rooms to form a series of committees to prepare for the reception of this Association in a fitting manner. The use of your building has been placed at their disposal, and considerable progress has since been made by the various committees. Your Council cannot allow it to pass

without recording the fact that the American Association for the Advancement of Science have chosen for their President Principal Dawson.

During the past year the Society held a field day at Montebello in conjunction with the Ottawa Field Naturalist's Club. This meeting was one of the most successful ever held by your Society, and the Ottawa Club expressed its complete satisfaction.

Your Council hope that many other field days in connection with the Ottawa Club may take place in the near future.

Your Council cannot omit this opportunity of thanking Mr. Papineau for the kind and generous manner in which he received the two societies, throwing open his splendid grounds and art gallery for their benefit.

REPORT OF THE TREASURER.

As Treasurer of the Society, Mr. Marler presented the following report and financial statement.

Your Treasurer is happy to report that the debt which has so long rested on your property has been paid off, also that 125 members have been added to your list of subscribers.

The building has undergone extensive repairs and alterations necessitated by the erection of houses against the north wall and otherwise.

The amount received from Mr. Thomas for the wall and ground ceded him was more than absorbed in paying for alterations and improvements. Finally, I have to report that your Society is now out of debt, and has on hand a balance of $156.09, and that during the year 3000 persons visited the Museum, three-fourths of the number free of charge.

FINANCIAL STATEMENT.

G. L. Marler, Treasurer, in account with The Natural History Society of Montreal, from May 19th, 1881, to May 18th, 1882.

Dr.		*Cr.*	
1881. May 18.		1881 and 1882.	
To Balance on hand	$ 74.54	By Improvements, Alterations, &c	$277.31
" Excursion tickets	33.50	" Excursion	55.40
" Rent of Rooms	535.00	" Wood and Coal	104.00
" Members Fees	290.00	" Gas account for year	84.20
" Entrance Museum	21.90	" Printing and Advertising	148.16
" Sale of Wall and Ground	204.69	" Insurance (three years)	55.00
" Government grant	700.00	" Petty expenses and repairs	67.82
		" Wages and Salary	293.35
		" Editing *Naturalist*	50.00
		" City Taxes (two years)	241.37
		" City for Water	24.70
		" Hy. Joseph Mortgage	268.00
		" Advertising	30.00
		" Lovell for Directory, &c	4.23
		" Balance on hand	156.09
	$1859.63		$1859.63

Mr. Wm. Muir then presented the

REPORT OF THE CABINET KEEPER AND OF THE LIBRARY COMMITTEE.

This report may be arranged under three divisions.

1.—Work on the Building.

2.—Work in the Museum.

3.—Report of the Library Committee.

1st. Work on the Building.—In consequence of the erection of a dwelling adjoining the north side of the building, three windows were closed up; the two in the Library were covered by bookcases and one in the Lecture-room plastered over. Two new Bird cases have been placed in the Museum. The whole drainage of the building has been remodelled, an entirely new drain put in and connected with the lower drain in Cathcart Street.

2nd. The work in the Museum has been of routine nature, the care of the specimens, the mounting and placing of the additions by purchase or gift.

Additions to Museum since June 1st, 1881.

DONATIONS WITH NAMES OF DONORS.

ANIMALS.

Red-winged Blackbirds, *Agelaius phœniceus*, male (2). G. L. Marler, Esq.
Two Grey Parrots, *Psittacus*. Mr. Carpenter.
Flying Squirrel, *Poterimys sabrinus*. Mr. W. F. Ferrier.
Brazilian Monkey. Mr. Papineau, of Montebello, P. Q.
(2) Golden Plover, *Charadrius Virginianus*. G. L. Marler, Esq.
Young Alligator. Mr. Percy Simpson.
Canadian Sponge. Prof. Fowler.

MINERALS.

Iron ore. Madoc. Pres. by G. L. Marler, Esq.
Tourmaline, with quartz and albite. Mount Mica, Paris, Me. W. F. Ferrier, Esq.
Mica. G. L. Marler. Esq.
Magnetic Iron Sand. G. L. Marler, Esq.
Magnetite. Port Henry, N.Y. W. F. Ferrier, Esq.
Precious Green Tourmaline and Rubelite. Paris, Me. W. F. Ferrier, Esq.
Colphonite with Graphite. Willsboro, N.Y. W. F. Ferrier, Esq.
Graphic Granite. Paris, Me. W. F. Ferrier, Esq.
Muscovite. Mount Mica, Paris, Me. "
Graphite. Willsboro, N,Y. "
Carbonate of Lime. Saratoga, NY. "
Lepidolite. Mount Mica, Paris, Me. "
Fibrous Serpentine. Rockland Quarry, P. Q. W. F. Ferrier, Esq.

J. Lorne McDougall, Esq., presented specimens of the following gums used in the manufacture of varnish.

Kowrie.
White Copal.
Pebbled Angola.
Damar.
Manilla.
Angola.
Gum belonging to a species of grass of Australia.
Benguilla, unbleached.
Shellac, bleached.
" unbleached.
Asaphaltum.

LIST OF BIRDS PURCHASED.

Gull, *Larus Argentatus.*
Snowy Owls, *Strix Nyctea* (2).
Grebe, *Podiceps cornutus.*
Plover (young), *Charadrius.*
Spotted Sandpiper, *Tringa macularius.*
Grass Finch, *Emberiza graminea.*
Williamson Woodpecker, *Picus* (2). Florida.
Swallows, *Hirundo Americana* (2).
Black Woodpecker, *Picus.* Florida.
Pheasant, *Tetras.* Texas.
Ducks, *Anas* (2). Texas
Bittern, *Ardea.* European.
Sandhill Crane, *Grus Canadensis*
Horned Scremen. South American.
Long Billed Parrot, *Nestor Productus.* Australia.
Blue Waterhen, *Porphiris speciosus.* Australia.
" " (young).
Wattled Honey Eater., *Anthachaera coriculata.* N. S. Wales, Australia.
Gigantic Kingfisher, *Alcedo gigantea.* N. S. Wales, Australia.
New Holland Green King Don, *Alcyon Australis.* Australia
New Zealand Pigeon, *Carpophasa Nova Zealandiae.*
Snow Bunting (2), male and female, summer plumage, *Plectrophanes nivalis.*

3rd. Report of Library Committee.—Having received a grant of $100 from the Council and gifts of ten dollars each from Messrs. Joseph and Marler, your Library Committee is now about to carry out the suggestion made two years ago—that the periodicals and pamphlets that have accumulated in the Library should be bound. Tenders have been received and the material is being prepared for the binder.

Rev. R. Lindsay donated the following books to the Library:

Petrology. 2 Vol.
Darwin on South America.
Van Rensellier's Geology.
Jamieson's System of Minerology. 3 Vols.
Manual of Mineralogy. By J. Nichol, F.G.S.
Richardson's Geology and Palæontology.
Phillips Treatise on Geology. 2 Vols.

List of books, pamphlets and periodicals received into the Library during the year ending May 1st, 1882.

American Journal of Science.
Anniversary Memoirs of the Boston Society of Natural History. 1830–1880.
Canadian Antiquarian and Numismatic Journal, for the year.
Canada Medical and Surgical Journal, for theyear.
Canadian Entomologist.
Le Naturaliste Canadien.
Statutes of Canada.
Proceedings of the Rhode Island Historical Society. 1881–'82.
Proceedings of the American Philosophical Society. Nos. 106 to 110.
Geological Survey of Canada. Report of Progress. 1879–'80.
Canadian Sportsman, for the year.
Bulletin of the Natural History Society of New Brunswick. No. 1. 1882.
Annual Report of do.
Royal Microscopic Journal, for the year.
Quarterly Journal of Microscopical Science, for the year.
Proceedings of the Royal Geographical Society, London, for the year.
" " Society of London.
" Linnean Society of New South Wales, Sydney. Vol. 6. Nos. 1, 2, 3.
Flora of Essex County, Massachusetts. 1880.
Statistics of the Fisheries of Maine; Smithsonian Institution. 1881.
Report of the History and Present Condition of the Shore Cod Fisheries of Cape Ann, Mass., U.S.A.
American Naturalist, for the year.
Science Gossip, " "
Journal of the Royal Society of New South Wales. Vols. 13 and 14.
Scientific Transactions of the Royal Dublin Society. Vol. 1. Series 2.
Bulletin of the Buffalo Society of Natural Science. 1881.
Contributions from the E. M. Museum of Geology and Archæology or the College of New Jersey. July, 1881.
Bulletin of the U. S. Fish Commissioners.
Annual Report of the Entomological Society of Ontario. 1881.

Bulletin of American Museum of Natural History, Central Park. No. 1. December, 1881.

Transactions Ottawa Field Naturalist Club. 1880–'81.

" Literary and Historical Society of Quebec. 1880–1881.

" of Newcastle-upon-Tyne Natural History Society. Vol. 7. Part 2.

Journal of Cincinnatti Natural History Sociecty. Dec., 1881.

Journal of the Royal Geological Society of Ireland. Vol. 6. Part 1. 1880–'81.

Proceedings of the California Academy of Science. June 6th, 1881.

Reports of the Superintendent of Enucation, Province of Quebec. 1877–'78; 1880–1881.

Report of the Meteorological Service of the Dominion of Canada. 1880.

Proceedings and Transactions of the Nova Scotian Institute of Natural Science, Halifax, N. S. Vol. 5; part 3. 1880–'81.

Proceedings of the Rhode Island Historical Society. 1881–'82.

Transactions of the Academy of Science of St. Louis, Mo., U. S. A. Vol. 4; No. 2. 1882.

Annual Report of the United States Survey, By Clarence King. 1880.

Bulletin of the Essex Institute. Vol. 13; Nos. 7, 8, 9.

Medicinal Plants in New Brunswick. By Dr. G. M. Duncan, of Bathurst. 1881.

Middleton Scientific Association—Annual Address by the President, Jan., 1881.

Proceedings of the Academy of Natural Science of Philadelphia. Part 3. 1881.

Transactions of the New York Academy of Science. 1881–'82.

Annals of the New York Academy of Science. Vol. 1, No. 14; Vol. 2, Nos. 1 to 6.

Annual Report of the Middlesex Institute. 1881–'82.

" " Middletown (Conn.) Wesleyan University. 1880–1881.

Archives Neerlandaises des Sciences Exactes et Naturelles—Société Hollandaise des Sciences, Haarlem.

Neunter Jahresbericht des Westfälischen, Provinzial—Vereins, Munster Pro. 1880.

Zeitschrift der Deutschen geologischen Gessellschaft, Berlin. Vol. 22; Nos. 3 and 4. Vol. 23; Nos. 1—3.

Sitzungsberichte und Abhandlungen der Naturwissenschaftlichen Gessellschaft Isis, Dresden. 1881.

Archives Musée Tyler. 2nd Series; part 1st.

Achter Jahresberichte des Westfälischen.

Provinzial Vereins fur Wissenchaft und Kunst, pro 1879.

Berichte des Hydrotechnichen Comité's, Wien. 1881.

Abhandlungen der Mathematish-physischen classe der Kcnigl, class 12; No. 20, Nos. 5, 6. Leipzig, 1880.

Verhandlungen des Naturhistorisch-Medicinischen, Zu Heidelberg. 1881.

Nederlandsch Meteorologisch Jaarbock, for 1876 and 1880; Utrecht, 1880–'81.

Defense des Colonies V., Apparition et Réapparition en Angletérre et en Ecosse des Especes Coloniales Siluriennes de la Bohême, par Joachim Barrande. Nov. 1881.

Annals del Museo Nacionale de Mexico. Vol. 2; parts 4, 5, 6.

Meteorologiska Iakttagelser I Sverige, Sweden. 1875, 6, 7.

Ofersight af Kongl, Vetenskaps Akademiens Forhandlingar, Stockholm. 1877—1880.

Bihang till Kongl, Svenska Vetenskaps Akademiens Handlingar, Stockholm. 4 Nos. 1878–'80.

Lefnadsteckningar fver Kongl, Svenska Vetenskaps Akademiens Band 2. Stockholm. 1878.

Bulletins de L'Académe Royale des Sciences, des Lettres et des Beaux Arts de Belgique. Nos. 46, 47, 48. Bruxelles.

Annuaire ditto. 1879.

Mémoires de L'Académie des Sciences, Arts et Belles-Lettres de Dijon. 1880.

Actes de la Société D'Ethnographie, Paris. Vol. 8, Nos. 1, 2 1874–1875.

Anatomia Delle Plante Aquatche. By Filippo Parlatore. Firenze, 1881.

Processo Morboso del Colera Asiatico. By Filippo Pacini. Firenze, 1880.

Clinica Obstetrica. By Ernesto Grassi. Firenze, 1880.

Le Empereur Justinien et Son Œuvre Legistative. Par M. Jules Cauvet. Caen, 1880.

Liste des Griogérides. Par A. Prudhomme De Borre. Bruxelles, 1881.

The Secretary then read the

REPORT OF EDITORS OF "NATURALIST."

The Editors of the "Canadian Naturalist" beg to report that since last annual meeting of the Society, only two numbers of the Journal have been issued. A third, however, will be completed at an early date. Whilst it is matter for regret that it has been impossssble to issue four numbers within the year, your editors are pleased to state that in the numbers issued, as well as in that to be issued shortly, the matter is wholly original, and, with one exception, by Canadians.

Your Editors would recommend that the Society appoint them to attend to the distributing of the Journal to subscribers and to those with whom it is an exchange. They would also urge upon members of the Society the desirability of making an effort to secure material of a suitable character for insertion in their Journal.

On motion, the reports were received and adopted, and ordered to be printed in the *Naturalist.*

On motion of Dr. Edwards, the Society resolved to accept the invitation of Mr. Gibb to hold a field day at Abbotsford during June, and a committee was appointed to make arrangements for the visit.

Mr. W. F. Ferrier was unanimously elected a member of the Society.

THE ELECTION OF OFFICERS.

The election of officers was then proceeded with and resulted as follows:—

President—Principal Dawson, LL.D., F.R.S.

Vice-Presidents—Rev. Dr. DeSola, Mr. J. H. Joseph, Prof. P. J. Darey, Dr. T. Sterry Hunt, Major H. Latour, Rev. Canon Baldwin, Dr. Hingston, Prof. B. J. Harrington, and Mr. D. A. P. Watt.

Recording Secretary—Prof. F. W. Hicks, M.A.

Corresponding Secretary—Dr. J. Baker Edwards.

Treasurer—Mr. G. L. Marler.

Cabinet-Keeper and Librarian—Mr. Wm. Muir.

Council—Messrs. Thos. Craig, J. T. Donald, J. Bemrose, Dr. Osler, M. H. Brissette, John S. Shearer, G. Sumner, and J. H. R. Molson.

Library Committee—Messrs. W. Muir, J. Bemrose, J. S. Shearer, and J. T. Donald.

Editor of Canadian Naturalist—Mr. J. T. Donald.

BIOLOGY NOTES.

By Professor Osler, M.D., McGill College.

I.—*On a remarkable vital phenomenon observed at Lake Memphremagog.*

During the first week in September, 1881, the water of the lake presented a peculiar appearance, owing to a number of minute green particles floating in it. In places they were so thickly crowded together that the water was of a deep green colour. Except near shore, they did not float on the surface but were diffused through the water to the depth of several feet. It was suggested to me by a friend that they were pollen grains, but their diffusion through the water and the season of the year seemed against this. They looked not unlike *Volvox globator*, but I have never seen this alga in such profusion. Fortunately, I had my microscope with me and the question was soon settled. Each little green mass formed a gelatinous ball, about one-thirtieth of an inch in diameter and enclosed numerous unbranched beaded filaments and proved to be a Nostoc—*Nostoc minutissimum*—a minute confervoid alga met with in water and in moist places. It is not a very uncommon species in our ponds, the remarkable point is the extraordinary profusion in which it occurred. The *Nostoc commune* is plentiful in the ponds at the Mile End, forming irregular green balls the size of a horse-chestnut.

The *Nostoc foliaceum* also occurs there; it has a membranous somewhat folded frond, usually growing erect on damp clay.

II.—*On the occurrence of Ophrydium versatile.*

This infusorian is met with in many of our lakes, particularly those to the north of the St. Lawrence. Its macroscopic characters are plant-like as it forms irregular greenish masses of a gelatinous consistence and though usually somewhat flattened, they may occur as beautiful globular bodies of a light green color. At Lac a l'eau Claire, in the property of Mr. G. W. Stephens, I found one mass the size of a large apple. On examination the gelatinous substance is seen to be colorless but imbedded in its cortex are numerous greenish infusoria with very extensible spindle-shaped bodies which are anchored by a delicate terminal filament in the matrix. When extended the body measures about one-hundredth of an inch,

when contracted it forms an elongated oval. The anterior extremity is blunt and fringed with cilia; a narrow elongated gullet can be seen but the body cavity appears protoplasmic and contains chlorophyl grains and nuclei. The naked eye appearances of this remind one of the *Nostoc* or of the gelatinous masses of the *Palmellaceæ.* It occurs extensively throughout Canada. I have found it in Burlington Bay, the Humber ponds near Toronto, the marshes about Lakes Simcoe, Couchiching and Muskoka. Nowhere have I met with it in such profusion as in Lac a l'eau Claire. In Lake Roberta, near Grenville, I found some very large masses.

III.—*On the distribution of Pectinatella magnifica in Canada.*

I stated in the brief notes in Canadian fresh-water Polyzoa which I read at one of the meetings of the Society last year, that the large Polyzoon above named had not been met with in Lower Canada. Since then I have found it in beautiful masses in Fitch Bay, Lake Memphremagog, and Dr. Harrington has obtained several fine specimens in the North river, near St. Andrews. In Ontario it has been found in Rice Lake in the Humber ponds and in greatest profusion in the Desjardins canal and the contiguous marshes. It is probably widely distributed in quiet ponds and swamps throughout the country, never in the open lake or in very clear water.

(*To be continued.*)

"On the results of Recent Explorations of Erect Trees containing Reptilian Remains in the Coal Formation of Nova Scotia." By J. W. Dawson, C.M.G., LL.D., F.R.S., &c. *Abstract of a Memoir read before the Royal Society, January* 12th, 1882.

The explorations referred to were carried on chiefly in the beds at Coal Mine Point, South Joggins, Nova Scotia; and their object was to make an exhaustive examination of the contents of erect trees found at that place and containing remains of Batrachians and other land animals.

A detailed section is given of the beds containing the erect

trees in question, with lists of their Fossil remains. The most important part of the section is the following:—

	ft.	ins.
Sandstone with erect *Calamites* and *Stigmaria* roots	6	6
Argillaceous sandstone, *Calamites*, *Stigmaria*, and *Alethoperis lonchitica*	1	6
Gray shale with numerous fossil plants, and also *Naiadites*, *Carbonia*, and fish scales	2	4
Black coaly shale, with similar fossils	1	1
Coal with impressions of *Sigillaria* bark	0	6

On the surface of the coal stand many erect *Sigillariæ*, penetrating the beds above, and some of them nearly three feet in diameter at the base and nine feet in height. In the lower part of many of these erect trees there is a deposit of earthy matter, blackened with carbon and vegetable remains, and richly stored with bones of small reptiles, land snails, and millipedes. Detailed descriptions of the contents of these trees are given, and it is shown that on decay of the woody axis and inner bark they must have constituted open cylindrical cavities, in which small animals sheltered themselves, or into which they fell and remained imprisoned. These natural traps must have remained open for some time on a sub-aerial surface.

In all twenty-five of these erect trees had been discovered and extracted, and the productive portions of them preserved and carefully examined. Of these fifteen had proved more or less productive of animal remains. From one, no less than twelve reptilian skeletons had been obtained. In a few instances not only the bones, but portions of cuticle, ornamented with horny scales and spines, had been preserved.

The Batrachains obtained were referred to twelve species in all. Of these two were represented so imperfectly that they could not be definitely characterised. The remaining ten were referable to the two family groups of *Microsauria* and *Labyrinthodontia*.

The *Microsauria* are characterised by somewhat narrow crania, smooth cranial bones, simple or non-plaited teeth, well-developed limbs and ribs, elongated biconcave vertebræ, bony scales and plates on the abdomen, and horny scales, often ornate, on the back and sides. They show no traces of gills.

The species belonging to this group are referred to the genera *Hylonomus*, *Smilerpeton*, *Hylerpeton*, and *Fritschia*. The characters of these genera and of the several species are given in

detail and illustrated by drawings and photographs, including microscopic delineations of the teeth of all the species, with their internal structure and the microscopic structure of their bones, as well as representations of their cuticular ornamentation and armour.

The Labyrinthodonts are represented by only two species of *Dendrerpeton*, which are also described and delineated.

About half of the reptilian species described are new, and those previously described from fragmentary remains are now more fully characterised, and their parts more minutely examined.

The invertebrate animals found are three species of land snails and five of myriapods, besides specimens supposed to represent new species of myriapods and insect larvæ, not yet fully examined, and which have been placed in the hands of Dr. Scudder, of Cambridge, U. S.

The memoir, consisting in great part of condensed descriptions of the facts observed, does not admit of much abridgement, and cannot be rendered fully intelligible without the accompanying plans, sections and drawings. It closes with the following general statement:—

"The negative result that, under the exceptionally favourable conditions presented by these erect trees, no remains of any animals of higher rank than the *Microsauria*, and *Labyrinthodontia* have been found deserves notice here. It seems to indicate that no small animals of higher grade inhabited the forests of Nova Scotia at the period in question; but this would not exclude the possibility of the existence of higher animals of a larger size than the hollow trees were capable of receiving. Nor does it exclude the possibility of higher animals having lived contemporaneously in upland situations remote from the low flats to which our knowledge of the coal formation is for the most part confined. It is to be observed also that as some of the reptilian animals are represented only by single specimens, there may have been still rarer forms, which may be disclosed should other productive trees be exposed by the gradual wasting of the cliff and reef."—*Nature.*

Meteorological Results for the Year 1881.

McGill College Observatory, Montreal, Canada. C. H. McLeod, Superintendent, Height above sea level, 187 feet.

Month.	Thermometer.				Barometer.				†Mean Pressure of Vapour.	‡Mean relative humidity
	Mean	Max.	Min.	Range.	Mean.	§ Max	Min.	Range.		
January	10.04	34.9	-13.6	48.5	30.1036	30.658	29.512	1.146	.0601	77.7
February	17.62	44.0	-16.4	60.4	30.1476	30.866	29.184	1.682	.0924	77.2
March	30.10	46.0	9.5	36.5	29.7497	30.308	29.236	1.072	.1366	80.5
April	38.98	74.0	8.3	65.7	29.8117	30.359	29.317	1.042	.1439	58.4
May	57.73	86.1	31.5	54.6	30.0148	30.466	29.703	0.763	.3365	68.6
June	61.04	81.8	38.0	43.8	29.8386	30.177	29.450	0.727	.3348	61.3
July	69.20	93.9	53.7	40.2	29.8468	30.275	29.423	0.852	.4909	69.8
August	69.41	91.1	52.2	38.9	29.9594	30.311	29.487	0.824	.5346	74.5
September	64.06	87.0	42.0	45.0	30.0231	30.349	29.767	0.582	.4639	75.7
October	43.85	74.0	23.0	51.0	30.0621	30.594	29.418	1.176	.2357	75.8
November	32.69	63.2	-5.5	68.7	30.0539	30.621	29.385	1.236	.1615	76.7
December	28.47	44.4	-1.0	45.4	30.0[illegible]07	30.657	29.047	1.610	.1418	82.3
Means for 1881	43.599	68.37	18.47	49.89	29.9685	.....	.....	1.0593	.26106	73.21
Means for 7 years ending with '81.	42.633	....	.....	....	29.9634	.....	.....	......	.25691	74.15

Month.	Wind.		Sky clouded per cent.
	Mean velocity in miles ℔ hour	Mean. direction.	
January	12.64	S. W. by W.	57.9
February	11.69	S. W.	62.1
March	12.84	N. W. by W.	75.2
April	12.63	N. W.	44.9
May	10.65	N. E. by N.	60.4
June	9.27	W.	60.7
July	8.06	W.	58.0
August	9.01	W.	57.1
September	9.35	S.	61.4
October	10.97	S. S. W.	65.4
November	12.97	S. W.	74.1
December	13.58	S. W. by W.	73.1
Means for 1881	11.138	W. S. W	62.52
Means for 7 years, ending with 1881	11.086		6 .09

* Barometer reduced to 32° Fah. and to sea level.
† Inches of mercury.
‡ Relative saturation being 100.
The monthly means are derived from observations taken every fourth hour beginning with 3.13 a.m.

The greatest heat was 93.9, on the 10th July; greatest cold was 16.4° below zero on the 2nd of February; extreme range of temperature for the year, 110.3°; greatest range of thermometer in one day was 41.6° on the 14th of January; the warmest day was July 10th, the mean temperature being 82.8°; the coldest

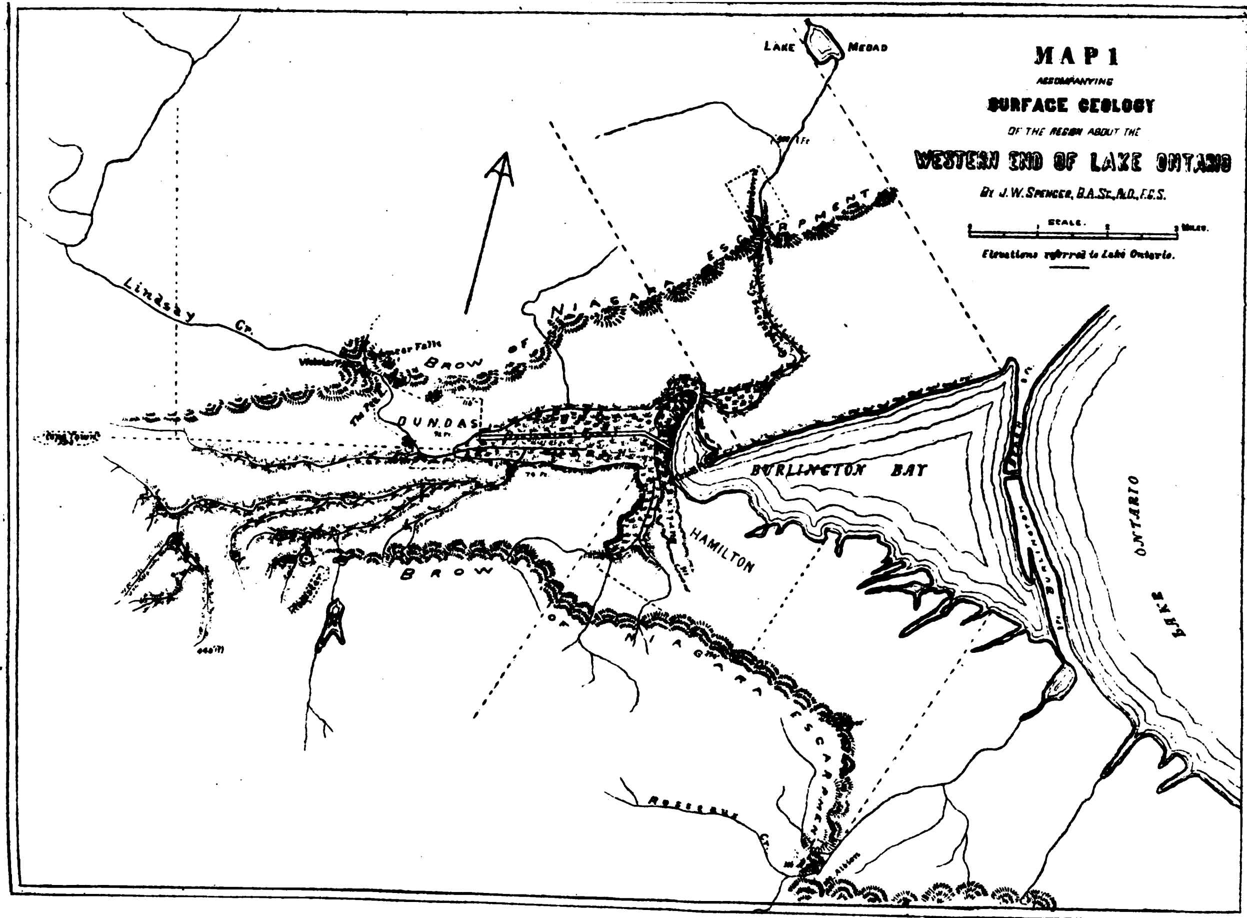
day was January 15th, the mean temperature being 8.57° below zero; highest barometer reading was 30.866 inches on 6th of February; lowest barometer reading was 29.047 inches, on 30th of December, giving a range for the year of 1.819 inches; the lowest relative humidity was 22 on April 16th; greatest mileage of wind recorded in one hour was 36, on January 14th; greatest velocity was at the rate of 48 miles per hour, on May 16th.

NOTES.—The sleighing of the winter 1880-81 closed on the 21st of April. There was not sufficient snow at any time during the remainder of the year to form good sleighing. The first snow for the autumn fell on October 5th, but was not appreciable. The first snow fall of more than one-tenth inch was on November 12th. The winter ice-roads were declared impassable on April 9th. The first ice shove occurred on April 10th. The first arrival in port was on April 19th. Auroras were observed on 29 nights. Lunar coronas were observed six nights, and lunar halos on 29 nights. Solar halos on 4 days, and coronas on 2 days.

RAIN AND SNOW FALL DURING 1881.

MONTH.	Inches of rain.	No. of days on which rain fell.	Inches of snow.	No. of days on which snow fell.	Inches of rain and snow melted.	No. of days on which rain *and* snow fell.	No. of days on which rain *or* snow fell.
January	r	1	26.5	18	2.70	1	18
February	2.04	5	7.3	11	2.76	3	13
March	0.24	8	39.1	21	4.39	5	24
April	0.44	7	0.4	8	0.48	2	13
May	3.25	21	0.0	0	3.25	0	21
June	1.39	12	0.0	0	1.39	0	12
July	3.31	18	0.0	0	3.31	0	18
August	2.08	10	0.0	0	2.08	0	10
September	1.93	11	0.0	0	1.93	0	11
October	3.80	19	0.1	5	3.81	3	21
November	1.09	14	11.8	13	2.19	4	23
December	3.25	12	4.4	12	3.63	4	20
Totals	22.82	138	89.6	88	31.92	22	204
Means for seven years ending with 1881	27.05	137.6	114.1	85.6	38.51	17.1	206

Published 27th June, 1882.



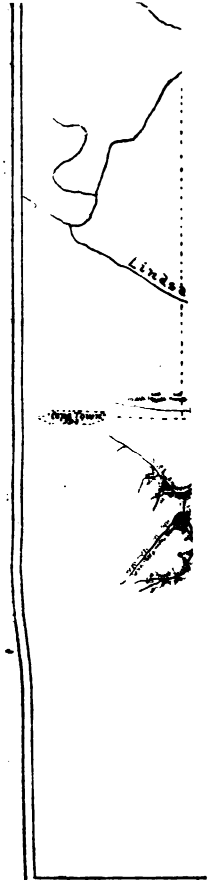
MAP 1
ACCOMPANYING
SURFACE GEOLOGY
OF THE REGION ABOUT THE
WESTERN END OF LAKE ONTARIO
By J. W. Spencer, B.A.Sc., Ph.D., F.G.S.
SCALE.
Miles.
Elevations referred to Lake Ontario.
LAKE MEDAD
LAKE ONTARIO
BURLINGTON BAY
BURLINGTON
HAMILTON
DUNDAS
BROW OF NIAGARA ESCARPMENT
BROW OF NIAGARA ESCARPMENT
Lindsay Cr.
Rousseaux Cr.

THE

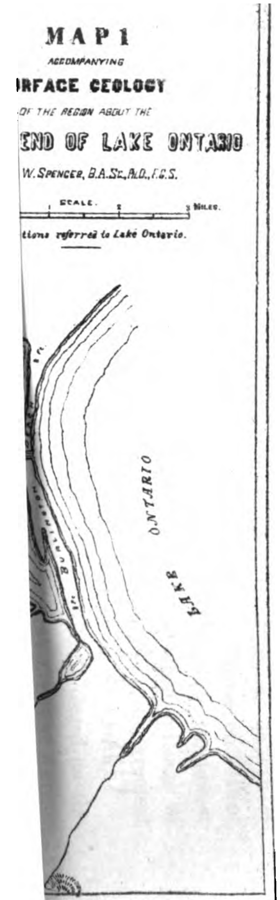
CANADIAN NATURALIST

AND

this spirit, to encourage its beginnings, and to extend the influence of its example, should be the aim of wise statemen and legislators who seek to elevate their kind and ennoble their nation: knowing that the brightest glories and the most enduring honors of a country are those which come from its thinkers and its scholars.



Lindsa



MAP 1
ACCOMPANYING
IRFACE GEOLOGY
OF THE REGION ABOUT THE
END OF LAKE ONTARIO
W. SPENCER, B.A.Sc., Ph.D., F.G.S.
SCALE.
3 Miles.
tions referred to Lake Ontario.
LAKE
ONTARIO
BURLINGTON

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

THE RELATIONS OF THE NATURAL SCIENCES.

By T. Sterry Hunt, LL.D., (Cantab.) F.R.S.

(The President's address before the Mathematical, Physical and Chemical Section of the Royal Society of Canada, at the first meeting of the Society, Ottawa, May 27, 1882.)

The occasion which brings us together is one which should mark a new departure in the intellectual history of Canada. Science and letters find but few votaries in a country like this, where the best energies of its thinkers are necessarily directed to devising the best means of subduing the wilderness, opening the ways of communication, improving agriculture, building up industries, and establishing upon a proper basis schools in which the youth of the country may be instructed in those arts and professions which are among the first needs of civilized society. The teachers under such conditions can do little more than interpret to their pupils so much of the wisdom of the past, and of contemporary science, as may suffice for the immediate wants of the country, and will have but scanty leisure for original investigation in the field of knowledge. There are however never wanting earnest and curious minds who feel an almost irresistible impulse to labor in this field, to enlarge the bounds of thought, and to grapple with the great problems of man and nature. To foster this spirit, to encourage its beginnings, and to extend the influence of its example, should be the aim of wise statemen and legislators who seek to elevate their kind and ennoble their nation: knowing that the brightest glories and the most enduring honors of a country are those which come from its thinkers and its scholars.

The world's intellectual workers are, from the very nature of their lives of thought and study, separated in some degree from the mass of mankind. They feel however not less than others the need of human sympathy and co-operation, and out of this need have grown academies and learned societies devoted to the cultivation of letters and of science. The records of these bodies in Florence, in Rome, in Paris, in London, and elsewhere, are the records of scientific progress for the last three centuries. Such bodies do not create thinkers and workers, but they give to them a scientific home, a centre of influence, and the means of making known to the world the results of their labors.

It was with a wise forethought that more than a century since Franklin and his friends founded at Philadelphia the American Philosophical Society. Its planting then seemed premature, but its vigorous growth during a century has served to show that the seed was not too early sown This, however, unlike many of the academies of the old world to which we have adverted, had no formal recognition from the state, and there came a period in the growth of the American Union when the need of an official scientific body was felt. Thus it was that nineteen years ago, in the midst of the great civil war, the American Congress authorized the erection of a National Academy of Sciences to which, as an American citizen, I have the honor to belong. The aim proposed in founding this Academy was to gather together what was best and highest in the scientific life of the nation, and moreover, to organize a body of councillors to which the executive authority could always look for advice and direction in scientific matters relating to the interests of the State. In that Academy—at first consisting of fifty, and now practically limited to one hundred members (a number which it has not yet attained)—the domain of letters is unrepresented; while the Royal Society of London is in like manner,—although scholars and statesmen seek the honors of its fellowship,—essentially an Academy of Sciences.

Our infant organization attempts a larger plan, and embraces with the mathematical and physical sciences, letters, philosophy, and history, imitating the Royal Irish Academy, which, like this, is divided into two classes; that of the Sciences, on the one hand, and that of Polite Literature and Antiquities on the other. The Institute of France, made up of five Academies, embraces the Fine Arts in its still wider scheme. The second class of our Society, with its two sections, aspires to cover the same

ground as the Academy of Sciences of the Institute of France, the Science division of the Royal Irish Academy, the Royal Society of London, and the National Academy of Sciences of the United States.

The two sections into which our second class is now divided, namely III. including Mathematic, Physic and Chemistry, and IV. embracing Biology and Geology, are, in their aims and their objects, closely related to each other, and widely separated from sections I. and II. which are devoted respectively to French and English Literature and History Differences in language thus establish in the literary department of this society a natural division into two sections. In the department of the sciences, however, there is no natural basis for a similar division, and it will probably be found in the near future that subjects of common interest will draw more and more closely together our two sections until, as in the various societies which we have named, the distinction between mathematical, physical and chemical studies on the one hand, and geological and biological studies on the other, will be lost sight of. It seems to me therefore fitting that we should in this time and place consider the mutual relations of these two divisions, and inquire into the value of the distinctions upon which they have been based.

Apart from pure mathematic, which is based upon our intuitions of space, the sciences which now concern us have to do with material nature, and are properly called natural sciences. It is not their province to look behind or beyond the material world of nature, nor to grapple with the mystery of the Infinite with which, in the last analysis, the inquirer always finds himself face to face. Our various metaphysical systems are schemes which men have devised to solve this mighty problem, and to translate into intelligible language their efforts to comprehend it. What we call Nature is at once a mantle and a veil in which the spiritual both clothes and conceals itself. "I weave," Goethe makes the world-spirit say, "the living garment of the Deity." This phrase embodies a profound truth. All nature is living; it is, as the word *natura* itself, equally with its Greek equivalent, *physis*, implies, that which is growing, the perpetually-becoming or being born; and this sense, which underlies etymologically the words *natural* and *physical*, should never be lost sight of.

It is a common reproach in the mouths of certain cavillers at science that it does not explain the beginnings of life in matter.

That the plant and the animal are living, is evident to them, but they assume that the air, the water and the earth, the elements from which the plant grows and is fed, are dead; that life is a mysterious something which comes from without, and is extraneous to the organism. Perhaps we may trace the origin of this conception to the ancient legend, which appears in more than one form, of a human body fashioned out of dead matter and waiting for vivifying breath or fire. The student of inorganic nature, however, soon learns to recognize the fact that all matter is instinct with activities, and finds that a great number of those processes which were formerly regarded as functions of organized bodies are really common to these and to inorganic matter. The phenomena of gravitation, of light and of electricity, the diffusion and transpiration of gases and liquids, the crystallogenic process, and the peculiar relations of colloids, are all, when rightly understood, manifestations of energies and activities which forbid us to speak of matter as dead. To all of these dynamical (or as they are generally called, physical) activities of matter, supervene those processes which we name chemical, and which give rise to new and specifically distinct inorganic forms. The attaining of individuality by matter, which has always seemed to me the greatest step in the progress of nature, is first seen in the crystal, but therein the forces of matter are in a static condition, except so far as certain dynamical relations are concerned. It is not until solid matter rises from the crystalline to the higher condition of the colloid, that it becomes capable of absorption, diffusion and even of assimilation; that, in a word, it assumes relations to the external world which show that it possesses an individuality higher than the crystal, and is, in fact, endowed with many of the activities belonging to those masses of colloidal matter which biologists have agreed to call living.

In these phenomena we have the first developments of individuality and of organization, and I think that the careful student who endeavours with a strong mental grasp to seize the true relations of things will see that we have here to do, not with a new activity from without, but with a new and higher development of a force which is inherent in matter, and thus manifests itself at a certain stage in chemical development. He will then, in the words of a philosophic poet,

> "See through this air, this ocean and this earth,
> All matter quick, and bursting into birth."

The adjective, quick, is here to be understood in its primitive sense of living, as opposed to dead, and aptly defines the notion which I have endeavored to convey. All the energies seen in nature, are in this view, but manifestations of the essential life or quickness of matter, whether displayed in the domain of what are called dynamical or physical activities, in chemical processes, or in the phenomena of irritability, assimilation, growth and reproduction which we may comprehensively designate as biotical.

When we have attained to this conception of hylozoism, of a living material universe, the mystery of nature is solved. The Cosmos is not, as some would have it, a vast machine wound up and set in motion with the certainty that it will run down like a clock, and arrive at a period of stagnation and death. The modern theory of thermodynamic, though perhaps true within its limitations, has not yet grasped the problem of the universe. The force that originated and impelled, sustains, and is the Divine Spirit, which

> "Lives through all life, extends through all extent,
> Spreads undivided, operates unspent."

The law of birth, growth and decay, of endless change and perpetual renewal, is everywhere seen working throughout the Cosmos, in nebula, in world and in sun, as in rock, in herb and in man, all of which are but passing phases in the endless circulation of the universe, in that perpetual new birth which we call Nature. This, it will be said, is the poet's view of the external world, but it is at the same time the one which seems to me to be forced upon us as the highest generalization of modern science.

The study of Nature in its details presents itself to the mind in a two-fold aspect,—as historical and as philosophical. The first of these gives rise to a General Physiography or description of nature, which we commonly call Natural History as applied to each of the three great divisions designated as the mineral, vegetable and animal kingdoms. This physiographic method of study in the latter two gives us systematic and descriptive botany and zoology, with their classification and their terminology; while the physiography of the mineral kingdom includes not only systematic and descriptive mineralogy, as generally understood, but those branches of geology which we designate as petrography and geognosy, or the study of the constituents of the earth's crust, their aggregation and their distribution.

The second aspect of the study of nature, which we have designated as philosophical, regards the logic of nature, or what the older writers spoke of as General Physiology. This, is sometimes appropriately termed Natural Philosophy, a designation which is the correlative of Natural History. With this method of study in the organic kingdoms we are familiar under the names of physiological botany and physiological zoology, which concern themselves with anatomy, organography, and morphology, and with the processes of growth, nutrition and decay in organized existences. The natural philosophy of the inorganic world investigates the motions and the energies of the heavenly bodies, and then, coming down to our planet, considers all the phenomena which come under the head of dynamic or physic, as well as those of chemistry. These various activities together "constitute the secular life of our planet. They are the geogenic agencies which in the course of ages have moulded the mineral mass of the earth, and from primeval chaos have evolved its present order, formed its various rocks, filled the veins in its crust with metals, ores, gems and spars, and determined the composition of its waters and its atmosphere. They still regulate alike the terrestrial, the oceanic and the aërial circulation, and preside over the constant change and decay by which the surface of the earth is incessantly renewed, and the conditions necessary to organic life are maintained." * Thus the physiological study of the inorganic world, or in other words, its natural philosophy, includes in its scope at once theoretical astronomy and theoretical geology or geogeny.

The two-fold division which has been adopted in the scientific class of our new society does not correspond to that which we have just set forth; namely, of natural history on the one hand and natural philosophy on the other; nor yet, as might at first seem to be the case, to the more familiar distinction between inorganic and organic nature. Our section III. has been made to embrace, it is true, much both of the natural history and the natural philosophy of the inorganic world, including besides physic, and chemistry, both descriptive and theoretical astronomy, and mineralogy. This same section has also been made to include

* The Domain of Physiology, or Nature in Thought and Language, by T. Sterry Hunt; London, Edinburgh and Dublin Philosophical Magazine. ([V.] xii. 233–253,) for October, 1881.

mathematic, which in itself, does not belong to the domain of natural science, though in its applications it becomes an indispensable instrument in the study of nature, whether we investigate the phenomena of physic or of chemistry, or seek to comprehend the laws which regulate alike the order of the celestial spheres, the shapes of crystals, and the forms of vegetation.

Section IV, on the other hand, in its department of biology, includes alike the Natural History and the Natural Philosophy of the vegetable and the animal kingdoms. In this same section has, however, been included what we call geology, which is not a separate science, but the application alike of mathematic and of all the natural sciences to the elucidation of both the physiography and the physiology of our planet. So far as geology concerns itself with the history of past life on the earth, or what is called paleontology, it is biological, but in all its other aspects the relations of geology are with section III. The logical result of this complex character of geology should be either the separation of paleontology from the other branches of geological study, which find their appropriate place in our section III, or else the union of the two sections through this their common bond.

It will be noticed that in this brief survey of the field of natural knowledge I have not spoken of the technical applications of science, nor alluded to its important aspects in relation to the material wants of life. On this theme, did time permit, I might speak at length. There are two classes of motives which urge men to the pursuit of knowledge; on the one hand, those of worldly fame or profit, and on the other, the far nobler sentiment which has the finding-out of truth for its object. It would seem as if by a spiritual law, the great principles which are most fruitful in material results are not revealed to those who interrogate nature with these lower ends in view. Newton, Darwin, Faraday, Henry, and such as they, were not inspired by a desire for the praise of men, or for pecuniary reward, but pursued their life-long labors with higher motives, the love of truth for its own sake, the reverent desire to comprehend the hidden laws and operations of the universe. To such and to such alone does nature reveal herself. In the material as in the moral order, the promise of achievement is given to those who strive after knowledge and wisdom irrespective of the hope of temporal reward, and the history of science shows that it is such seekers

as these who have attained to the discovery of those secrets which have been of the greatest benefit to humanity. The admonition is to all, that we are to seek first for truth and for justice, and with this comes the promise that to those who thus seek all other things shall be superadded.

It is good and praiseworthy to labor to extract the metal from the ore, and the healing essence from the plant, to subdue the powers of electricity and of steam to the service of man. To those who attain these ends the world gives its substantial rewards, but far higher honors are instinctively rendered to those who by their disinterested researches, undertaken without hope of recompense, have revealed to us the great laws which serve to guide the searchers in these fields of technical science; to those who have labored serenely, with the consciousness that whatever of truth is made known by their studies will be a lasting gain to humanity. "Thus," to repeat words used on another occasion,* "it ever happens, in accordance with the Divine order, that the worker must lose himself and his lower aims in his work, and in so doing find his highest reward; for the profit of his labor shall be, in the language of one of old, to the glory of the Creator and to the relief of man's estate."

---

* The relations of Chemistry to Pharmacy and Therapeutics, an address before the Massachusetts College of Pharmacy, by T. Sterry Hunt; Boston, 1875.

SURFACE GEOLOGY OF THE REGION ABOUT THE WESTERN END OF LAKE ONTARIO.

By J. W. Spencer, B.A.Sc., M.A., Ph.D., F.G.S.,
Vice-President of the University of King's College, Windsor, Nova Scotia.

(For previous parts, see this Journal, Vol. X., Nos. 3 and 4.)

At the time when the "Preglacial outlet of the Basin of Lake Erie, &c." was written (Feb. 1881) I felt confident that the Preglacial outlet of Lake Ontario would be more or less easily revealed, and therefore neglected to give due consideration to the erosion that would be effected by the action of the rain and rain-water. This may well be summed up by quoting from a criticism on my above mentioned paper, by Prof. J. P. Lesley, the Director of the Geological Survey of Pennsylvania* "For a number "of years I have been urging upon geologists, especially those "addicted to the glacial hypotheses of erosion, the strict analogy "existing between the submerged valleys of Lakes Michigan, "Huron and Erie, and the whole series of dry Appalachian "'Valleys of VIII,' stretching from the Hudson river to "Alabama; also of Green Bay, Lake Ontario and Lake Cham-"plain, with all the dry 'Valleys of II and III.' One single "law of topography governs the erosion of them all, without "exception, whether at present traversed by small streams or "great rivers or occupied by sheets of water; the only agency "or method of erosion common to them all being that of rain "water; not in the form of a great river, because many of them "neither are now nor ever have been great water-ways. As a "consequence of their absolute similarity of geological position, "general form and common genesis, their age must be one and "the same. The sea has had nothing to do with their production "for it has permanently invaded some of them, or even "temporarily others. Ice has had nothing to do with their

* See Report Q4 of that Survey, 1881.

"production, for those in the glacial regions differ in no respect "from those nearest the Gulf of Mexico. I also long ago urged "on theorists the necessity of taking into account as a prime "factor *the underground solution of limestone strata*, and the "subsequent aqueous removal of the fallen *débris* of overlying "strata, the roofings of caverns and the steeps of cliffs. . . . "A curious illustration is offered by the peninsula of Yucatan, "on the surface of which are no streams of water, the drainage "of the whole country being underground. It is useless to "repeat the oft-told demonstration; but it is well now that Dr. "Spencer has disembarrassed us of the chief difficulty of our "last pre-recent water-system of the north, to remind the "admirers of his great discovery that his new found ancient "Grand river did its work not only with the constant assistance "from the beginning to the end, of millions of smaller rivers, "creeks, runs, rills, but also in such subordination to them as a "general acknowledges to his troops, or a contractor to his army "of navvies. . . . Our Great Lake basins although traversed "by a great river, were not excavated by it, but by a universal "vertical descent of rain-water upon the areas, lowering their "surfaces gradually and nearly equally at all points while at the "same time mining it throughout the whole extent of its lime-"stone underfloor; the material being removed in the ordinary "way, by rills, rivulets, and the great rivers to the sea."

On former pages an attempt has been made to give the physical configuration of the bed of Lake Ontario, and but little was said about the former outlet of the basin because little is absolutely known.

Before considering the glacial theory of the excavation of the lake, let us examine where there could have been an outlet for the waters of this great river system.

Possibilities of an outlet by the St. Lawrence. The north-eastern portion of Lake Ontario is very shallow. Although the country surrounding it is low, yet it is underlaid by hard rocks which are so frequently exposed, through the moderate thickness of drift as to preclude the idea of a great buried channel existing adjacent to the St. Lawrence, which a short distance below the outlet of the Lake flows over Laurentian rocks. However, in northern New York, but southward of the St. Lawrence, there are some unimportant buried channels connected with the Ontario basin. The St. Lawrence river itself is modern from Lake

Ontario to the junction of the Ottawa river, though the lowest portion of the river is conspicuously of ancient date, with pot-holes indicating a depth of nearly 1200 feet. Without a considerable change of level, such as either that which would be produced by a local subsidence of north-eastern Ontario and the upper St. Lawrence, or a very great northern subsidence during a period of southern elevation, any possibilities of the preglacial outlet of Ontario basin by the St. Lawrence seems impossible. However, the oscillation hypothesis seems to be more and more supported by observation.

Possibilities of an outlet at the south-eastern end of the lake. Between the eastern shores of Lake Ontario and the foot of the Adirondacks, the broad plane appears to mark the former lake bottom before the lake contracted to within the present limits.

This remark holds good for the "Great Level" between the southern margin of the lake and the escarpment to the south, although 150 feet above it. The level country south-east of the lake is underlaid by almost horizontal Palæozoic rocks, which are exposed along many of the streams, and are covered generally with no great thickness of drift. These rock exposures occur as far south as a short distance north of Oneida lake. They are also seen along the Oswego river, and the lower portion of the Seneca. However, there is a deeply buried basin in the region of Onondaga lake. Oneida lake is only 60 feet deep, and 127 feet above lake Ontario, and is situated in a basin of drift.

Onondaga lake is 119 feet above Lake Ontario, and is about 65 feet in the deepest sounding. It is a modern lake situated in a great drift-filled basin. The shallower portion of this basin is toward the northern end of the lake, it increases in depth on approaching Syracuse, but again becomes somewhat shallower on passing southward of this city. The drift-filled basin reaches to a depth of about 290 feet below the surface of Lake Ontario. Southward of Syracuse the country rises to the escarpment forming the southern boundary of the Ontario valley.

For many years, suggestions have been made that the Preglacial outlet of Lake Ontario was by the buried basin just described, emptying its waters by the Mohawk and Hudson rivers into the Atlantic. However, this suggested outlet is not possible, without considerrble local change of elevation, as shown by Mr. Carll, for the Mohawk river passes over metamorphic rocks at Little Falls, Herkimer County, at an elevation above

Lake Ontario of about 125 feet, without the possibility of an adjacent buried channel through the range of hills, through which the Mohawk valley is cut. The Onondaga basin, then, appears to have been originated by a river extending from the Adirondack mountains westward, and emptying into the Ontario basin northward of the Cayuga lake, forming along the course the basin, now occupied by drift material and Onondaga lake, and perhaps that also of Oneida lake.

Most of the other lakes of central New York, especially those having a more or less meridional direction, lie in great valleys, and are only closed up ancient river valleys. All of these lakes, except two, Seneca and Cayuga, are at a considerable elevation. One of the deepest of these elevated lakes is Skeneateles (613 feet above Lake Ontario, and 320 feet deep). This lake, and Owasco lake, have northern modern outlets over rocky barriers. They lie in valleys several hundred feet deep (300 feet or more) and evidently emptied into the Susquehanna river in some former geological times. The valleys of these lakes as well as several river valleys in the region now having northern outlets (such as those of Onondaga, and Butternut creeks) all radiate from adjacent or common points as they extend northward, evidently shewing a former southern discharge. However, it is exceedingly difficult to determine how much of the valleys are of Preglacial, and how much of Interglacial or Postglacial date, for there are evidently three periods of erosion—the valleys produced in Interglacial and Modern epochs coinciding.

Thus far no apparent outlet of the great ancient Ontario basin has presented itself. One other route at first appeared possible —*by the Seneca Lake, Chemung and Susquehanna Rivers*. The features favoring this suggestion are: the greatest depth of Lake Ontario north of Seneca lake; the depth of Seneca lake, which is 612 feet (423 feet below the level of Lake Ontario): the direct continuity of Seneca lake valley with that of the Chemung, at Elmira, and of the latter valley with that of the Susquehanna, at Sayre. The valley of Chemung above Elmira is much smaller than the portion below, which joins it at a considerable angle, but this portion of the river just above Elmira is more modern than the Preglacial course of the Chemung, which from Corning passed directly to Seneca valley at Horse Heads. One thing is certain, the Ontario basin as it was emerging from the last subsidence of the ice age, flowed by the route indicated and lingered

sufficiently long at the level of the upper part of Seneca valley, to produce beaches at the same level along various portions of the margin of the basin.

Unless there was a great relative change of continental level, the route just described could not have been the Preglacial outlet of the basin of Lake Ontario, as a considerable portion of the *cañon* of the Susquehanna for several miles below Towanda (738 feet above the sea) "has a rocky bottom." Cayuga valley would not afford any better outlet, as its summit is 200 feet higher than that of the valley of Seneca lake, and connects with the Susqnehanna by diminished valleys.

A pot-hole at the mouth of Chesapeake Bay indicates an ancient depth of the Susquehanna River to at least 1170 feet below sea-level. Many of the streams in northern Pennsylvania, now tributaries of the Susquehanna, indicate an original northward flow to Seneca lake.

Oscillations of the Continent in the Lake region.—Until recently my investigations bearing on the origin of the great lakes have been mainly based on the hypothesis that the closing of the basins was not occasioned by the elevation of the lake margins, by means of the local elevation of the earth's crust. This hypothesis then necessitates the existence of buried channels being outlets of the lake basins, which, if their contained drift were excavated, would restore the Preglacial drainage. My recent observations in New York and elsewhere have failed to obtain any proofs of the existence of such channels.

Outside of the region of the lakes, in the Red river valley, there are known, at least, two deep bore-holes far apart where the drift extends to a level below that of Lake Winnipeg, and indicates that if the drift were removed from the Red-Minnesota valley the drainage of some of the great lakes and rivers of the Canadian North West territories would flow to the Mexican Gulf (as first pointed out by General Warren) without the necessity of a local change of level. This fact extended to the lake regions strengthened my opinions as to the correctness of the above hypothesis.

Whilst the fluviatile origin of Lake Ontario is apparent, yet the failure of demonstrating a drift-filled outlet for the basin (which is 500 feet below the level of the sea) has forced me provisionally to accept the hypothesis that the basin was partly closed by oscillations of the region, as strongly set forth in an able letter from Mr. G. K. Gilbert.

As an evidence of local oscillation, Mr. Gilbert has pointed out that the Irondequoit Bay, near Rochester, was excavated to the depth of more than 70 feet, and two miles wide, by streams of Post-glacial (or Inter-glacial) date, and subsequently submerged to the above depth. From this, his conclusion is that at the time of the excavation of this fiord-valley, the relative altitudes of the locality and the rock-sill over which Lake Ontario discharges differed from their present status by more than 70 feet. Corresponding perfectly with Irondequoit Bay is Burlington Bay at Hamilton, with a depth of 78 feet, with a closed beach across its mouth. From this and other local features, the surface geology of the Dundas valley would indicate a greater elevation, to the extent of more than 78 feet at the head than at the present outlet of the lake.

Let us consider for a moment the physical effect that would be produced upon the stratification by the subsidence of the north-eastern portion of Lake Ontario and the upper St. Lawrence. The dip of the rocks at the western end of Lake Ontario is about 25 feet in a mile, westward of south. At the eastern end of the lake, I believe, it is somewhat greater. The deeper portions of the lake are more than 40 miles from its present outlet. Any local depression gradually extending north-eastward from the deepest soundings of the lake, to even the extent of 25 feet in the mile, would lower the outlet by the St. Lawrence to an extent far greater than would be necessary to drain the lake, provided this change took place at a time of high continental elevation, thus producing a broad depressed valley. We know that the valley of the lower St. Lawrence is submerged to the depth of at least nearly 1200 feet. The rocky boundaries of the region could scarcely more than indicate this change of level as the dip of the rocks would pass from the condition of 25 feet in the mile or less to almost absolute horizontality, and we have no means of comparison. If, however, the elevations took place to the northward to a greater extent then the southward, such as might be occasioned by a change of the centre of gravity of the earth, then the region to the southward of the lakes might be relatively sufficiently lowered as to permit a portion of the drainage to pass out by either the Mohawk or Seneca Lake valleys, which evidently during some portion of the Ice Age discharged waters from the expanded basin of the lake. The local oscillations would also be necessary in the explanation of the complete closing of

the outlets of the lake by these routes (as also those of the upper lakes). Prof. Lesley seems to favor the hypothesis of the former outlet of the Ontario basin by the Mohawk and Hudson rivers, but points out that the valley is underlaid by solid rocks at Little Falls (Herkimer County) at an elevation of 350 feet above tide. Therefore the deepest portion of the lake would be 850 feet below this barrier in the great valley. In closing the paragraph, the above named distinguished geologist says that if the above route be correct, then the country about Little Falls must have been elevated (query: by the Mohawk uplifts, as items of a more general Hudson river uplifts) more than 900 feet. And this may possibly give us a rude geological date for the elevation of the Catskill "mountain plateau, sloping westward into Pennsylvania."

It is by no means necessary to assume that the local elevation which cut off any outlet to the sea, by either the St. Lawrence or Mohawk-Hudson rivers, took place during or at the close of the Ice Age for the period of the river-valleys just described dates far back in geological time. If the explanations brought forward be wholly correct, then the date of the commencement of the valleys should be placed after the close of the Palæozoic time, as the valley of the Susquehanna, and some of the ancient rivers entering the lake basins are partly excavated out of carboniferous rocks, which had been previously elevated. This would agree with the older portions of the Mississippi river. However, the Great River Age did not culminate until the middle Tertiary times, as shown by the tributaries of the ancient Mississippi.

In the Ice Age the outlets of the lakes were closed by drifts in addition to the agency of local oscillation. Whether the fillings of the valleys were produced by glacier-action, by the agency of icebergs, or by that of floating pan-ice, a rational explanation might be given; but as this depends upon unsettled glacial geology, I will not here delay by entering into discussion. However, there appears to be every evidence of an Inter-glacial epoch, when the greater portion of the present Dundas valley, the Niagara river, by the old buried channel of St. Davids, and many other valleys, everywhere in the lake region, were either re-ëxcavated in the drift, or originally opened; and that the second closing or filling of these valleys was not accomplished through any glacier action, but principally through the agency of pan-ice and currents.

Hypothetical Glacier Origin of the Lakes. The hypothesis that the lakes were excavated by glaciers will now be briefly examined. One cannot do better then give a summary of what Prof Whitney (in Climatic Changes) says with regard to the erosive power of ice. "Ice *per se* has no erosive power." Glaciers are not frozen to their beds. Ice permeated with water acts as a flexible body and can flow accordingly. In neither the glacier regions of California nor in the shrunken glaciers of the Alps will it be found that ice scoops out channels with vertical sides as water does.

"No change of form can be observed at the former line of ice. Aside from the morainic accumulations, there is nothing to prove the former existence of the glacier, except the smooth, polished or rounded surfaces of the rocks, which have no more to do with the general out line of the cross-section of the valley than the marks of the cabinet-maker's sandpaper have to do with the shape and size of the article of furniture whose face he has gone over with that material."

The most important work of a glacier is the scratching and grooving of surfaces. This may however, be done by dry rubbing, and therefore isolated scratched stones or patches are no evidence. The underlying rock surfaces may lose their sharpness, owing to contained detritus in the ice, and become rounded. The ground moraine is neither characteristic nor important. There is but little detrital material beneath Alpine glaciers, and this is the result of water more than ice. The only characteristics of ice action are striation and polishing. All floating ice shod with stones frozen in them will scratch surfaces over which they rub. The only glacial lakes that are formed are those where the pre-existing valleys have been closed by morainic matter, but the waters will soon re-öpen these dams by running over them.

Such are the deductions of the late Director of the Geological Survey of California, a man who has had opportunities for studying the action of glaciers better than most geologists in America. So far Prof. Whitney's investigations are applicable to our great lakes.

Mr. George J. Hinde, F.G.S., one of the few geologists who has written from a Canadian standpoint is an uncompromising glacialist. On the uncertain evidence of ice scratches in the north eastern end of Lake Ontario, and also on those of others in a similar direction at the western end of the lake, he asserts

that Lake Ontario was excavated by a glacier. Dr. Newberry accepts his statement, but considers that a Pre-glacial valley determined the direction of the continental glacier.

Mr. Hinde also asserts his belief that the buried valley of the Niagara river (by the way of St. David's) as also the valleys at Dundas and Owen Sound, are of glacier origin. We have proved incontrovertibly that Dundas valley is a buried river channel; also Owen Sound and the St. David's valley are both beds of Pre-glacial or Inter-glacial rivers.

Let us analyze the direction of the ice scratches in the neighborhood of the western end of Lake Ontario. I have not seen any (out of very many sets,) which parallel with the axis of either the Dundas valley (except *possibly* one polished surface in the valley), or the axis of the lake, but always at considerable angles. In the region of Kingston, the prevailing scratches are S. 45° W. (Bell) and some others at S. 85° W. neither of which directions are parellel with the axis of the lake. Granted that Mr. Hinde observed scratches that were parallel with the axis of the lake, they of necessity would have been at an angle with the submerged escarpment. If any glacier could have scooped out the basins of Lake Ontario, it left the summit edges of the Niagara escarpment as sharp as possible and not planed off. Also if it excavated the deep trough of the lake, it left a summit of soft Medina shales over the harder Hudson River rocks of the escarpment, beneath which are Utica shales. From Dundas to the Georgian bay the face of the escarpment (Niagara) is less abrupt, but even here, there has not been left more than 50 feet of drift at its foot, and this mostly, if not altogether, stratified (excepting in channels now buried.)

The observations of Professor H. Y. Hinde, on the coast of Labradore, are here interesting. He has shown that *pan-ice*, at the present time, is polishing the sides of cliffs, and has been continuing its action whilst the coast has been rising several hundred feet. Even under the ledges of overhanging rocks the action is now going on (a phenomenon which, if in the lake region, would be attributed to glaciers). Also, he has seen boulder-clay being formed at the present time by the action of *pan-ice* (frozen sea water). This, with a thickness of eight or ten feet gets piled up by the action of waves and wind, and consequently in the bays of the coast of Labrador it polishes rock bottoms to a depth of fifteen feet or more, below the surface of the water, and grinds

off rough surfaces. I have frequently seen, myself, in northern regions, high boulders transported by the ice to which they were frozen in the margin of small lakes.

From what has been written, it seems to the writer that the glacial origin of Lake Ontario does not rest on a single basis further than that ice scratchings (producible by either glaciers or icebergs, neither of which need be great erosive agents) are seen at various places about Lake Ontario, both above and below the water level. The remarks applied to Lake Ontario hold good for the other lakes. The description of their topography strengthens the proofs that their origin cannot be accounted for by glaciers, because we find the islands at the western end of Lake Erie, or northern end of Lake Huron, polished and striated.

One thing is certain, the valley of Lake Ontario is one of erosion —not of glacier-erosion—in operation, during much of the time that has elapsed since, at least, the close of the Palæozoic times, closed partly by drift, but also apparently by great geological uplifts, either along the Mowhawk-Hudson valley, or else the inconspicuous broad valley of the upper portion of the St. Lawrence river, formed a continuation of the Ontario plane, which in its north-eastern area became elevated, and now constitutes the shallow floor of the lake and the adjacent low uplands.

Age of Niagara River.—That the Niagara river is Post-glacial, at least from the Whirlpool to Queenston, is apparent. It is known that the Niagara river formerly left its present course near the Whirlpool and flowed down the valley of St. David, which is now filled with drift. This valley (through the limestone escarpment) is not so great as the present *cañon*. This buried valley of St. David could only have been produced after the closing of the Dundas valley outlet of the Erie basin, for until then the waters flowed at a very much lower level. Therefore, it seems necessary to regard this channel (not of very great magnitude) as an inter-glacial outlet for Lake Erie.

The geologists of the Western States point to the Forrest bed as a period of high elevation, preceded by the Erie clay (stratified) and succeeded by the yellow stratified clays or loam, corresponding to the Brown Saugeen clay of Canada, which is unconformable to the underlying Erie clays (or Boulder clays in the upper portion of the Dunday valley). So, for the present, we look upon the old course of the Niagara river as the channel excavated during this warm interglacial period.

Age of the Niagara Escarpment.—This is manifestly of Pre-glacial date, and owes its origin to subaerial and fluviatible action before the advent of the Ice Age.

V.—General Glaciation of the Country.

The glaciation of the eastern part of the Province of Ontario is generally south-eastward in the basin of the Ottawa river, but on the northern side of Lake Ontario it is generally south-westward until we pass the region of the Dundas valley.

The country north of Lakes Superior and Huron, as well as along the eastern portion of the latter lake, have the ice-markings also in a general south-west direction. But from the height of land between the three great lakes (Huron, Ontario and Erie), the striations are more frequently towards the south-east. This direction continues to the Townships of Beverley and the northern portion of West Flamboro. It also continues along the Grand river valley, in the Niagara peninsula, as is shown at York (a short distance east of Seneca). But along the Niagara escarpment, on the northern side of Dundas (in the township of West Flamboro) we find several sets of striations, the prevailing direction being westward, or a few degrees south of west. On the escarpment south of Ancaster and Hamilton there are several sets of ice-grooves, but these vary generally from S 40° W to S 60° W,—being more to the southward than those on the north side of Dundas. The same remark applies to the country farther eastward, even to the Niagara river. In many places two or even four or five different sets of ice-markings are seen.

The following table represents some of the principal glacial markings, adjacent to the western end of Lake Ontario.

List of Ice Grooves.

No.	LOCALITY.	DIRECTION.	
	West Flamboro (Township :—		
	Near "Peak," at Dundas, prevailing grooves..........................	W.	
	Near "Peak," at Dundas, other grooves.	N. 73° W.	
	" " " "	N. 83° W.	Some are curved in same set.
	" " " "	S. 87° W.	
	" " " "	S. 80° W.	
	About 2 m. S. Strabane (Bell)........	S. 49° E.	
	S. of Flamboro village (Bell)..........	S. 74 W. (with others S. 69° W.)	
	" " " "	S. 24° W.	

Beverley :—

Near Sheffield (Bell)	S. 72° E.
" " 1 m. south-west (Bell)	S. 46° E.
" " 2 m. south (Bell)	S. 89° E.
Near Troy (Bell)	S. 76° E.
1 m. S. of Sheffield and 2.5 east (Bell)	S. 79° E.

Ancaster :—

At Ancaster village (Bell)	S. 59° W.
2 m. east of Ancaster village (Bell)	S. 71° W.

Barton :—

At Rosseaux Quarry, lots 3 and 4, R. VII.	S. 40° W.
" Carpenter's " lot 7, R. VII	Older set S. 40° W.
" " "	Newer set, S. 57° W.
" " Limekiln, lot 15, R. VI	S. 57° W. (deeply gr'ved polished and striated.)
Near Asylum, on mountain, at Hamilton.	S. 65° W. (deep grooves 0.5-2 in. wide.)
At Russel's Quarry, head of James St., Hamilton, on a ledge of Medina sandstone, on side of escarpment, 254 feet above lake and 134 feet below summit	S. 80° W.
At York, on the Grand river (Bell)	S. 68° E.
At Whirlpool, Niagara river (direction of river about S. 75 E. to N. 75 W.)	S. 10° W.
At Niagara Falls (Bell)	S. 28° W.
At Rockwood (Bell)	S. 38° E.

In some cases the rocks presented a polished surface with numerous fine scratches, in others there are groovings a few inches broad, and perhaps one or two deep. In other places, again, there are deep troughs scooped out of the surface rock. One of the most interesting series of troughs is just north of the "Peak," at Dundas (at a height of 516 feet above Lake Ontario). Here the clayey earth has been removed, and the surface presents the appearance of a series of crests and troughs of waves, having a distance between the crests of about eight feet, with a depth varying from half to one foot—the direction of these is about S 65° W. Their surfaces are smoothed and polished and are again striated by several sets which cross them at small angles in a more western line. These ice-markings continue in straight lines, scratching both the troughs and crests (of the large grooves) equally. In some cases I have noticed acute bendings of the striations.

On the northern side of the Dundas valley the brow of the

escarpment is abrupt, not having the angle at the summit planed off, except on the western side of Glen Spencer, where 100 feet or more have been removed, by causes to be explained below. The brow of the escarpment on the southern side of the Dundas valley and Hamilton is equally abrupt with that on the northern side of the town of Dundas, but the immediate brow is about 100 feet lower. Nowhere in the region about Hamilton and Ancaster do we find the face of the escarpment with its angle planed off, although the top is in very many places ice-scratched to the very margin, in directions varying from 10 degrees or less, to 20 degrees, with its general trend.

The general axis of the Dundas valley may be placed at from N 70° E to S 70° W. Nowhere have I observed the striations parallel with its direction, except at about two miles east of Ancaster, and at another place at Hamilton; but this last, at Hamilton, requires further notice.

At Russel's quarry at the head of James Street, a large amount of clay and rubble, derived from the harder beds of the Clinton (and Niagara also) formation, was removed in order to quarry some of the upper beds of Medina sandstone. This sandstone is overlaid by a few feet of earthy dolomites of the Clinton divisions, these forming a ledge 254 feet above the lake and 134 below the summit of the mountain. Here I observed that the surface had been polished and scratched in the side of the escarpment at a depth of 134 feet, almost vertically below its brow. The direction was S. 80° W, or parallel with this margin of the Dundas valley, or the "Mountain." It is further worthy of remark that although the surface was polished, the striations were very faint.

VI.—POST PLIOCENE DEPOSITS.

Having noticed the general glaciated surfaces of the hard palæozoic rocks of the country, it becomes necessary to study the comparatively modern deposits which rest on them in order to understand the causes which produced the modern topography of the country.

The following table shows a classification of the geological epochs newer than the Pliocene Tertiary in America, represented in descending order:

IN WESTERN ONTARIO	IN EASTERN ONTARIO, QUEBEC, ETC.	EQUIVALENTS ELSEWHERE.
Recent Modern Era, represented by shell-marl, modern alluvium, etc. Older Modern Era, (excavations of valleys in terraces during a somewhat more elevated continent).	Modern Era.	Modern Era (of Europe). Reindeer, or Second Glacial Era of Europe.
Terraces and Beaches, (Artemisia gravel).	Terraces & Beaches.	Terraces and Beaches.
Algoma sand (?) Saugeen fresh-water clays, Forest bed (as of Ohio).	Saxicava sand.	Champlain Epoch (of Dana). Brick clay (with Arctic shells, Scotland). Kames (Scotland Morainic debris, perched blocks, gravels, with animal remains, (Scotland).
Erie clay (with few boulders)	Leda clay.	
Boulder clay (frequently absent).	Boulder clay.	Boulder clay, of Europe. Till, of Europe.
Striated rock.	Striated rock.	Striated rock.

VII.—THE TILL, ERIE AND OTHER CLAYS.

General Distribution of the Erie and Saugeen Clays.—The greater portion of the surfaces of the striated rocks of Ontario is covered by *Erie clay*. This clay is always stratified, sometimes with sandy partings, and is more or less calcareous. It is blue when wet, but of an ash-color when dry, and the upper portion is of very fine texture. It frequently contains rounded boulders, and according to Dr. Robert Bell, the lower portion includes a greater or smaller number of fragments which are angular when composed of palæozoic rocks. It contains no shells of marine origin. Some of the immediately overlying and closely associated deposits are known to contain a considerable fauna of fresh water shells. The Erie clay has been seen at various heights

above all the great lakes, and even reaching in the region of our Upper Great Lakes to a height of 1,000 feet above the sea, at Maganetawan river (Bell). It occurs along Lake Ontario at the mouth of Niagara river, at Thorold and westward. In the eastern part of the Dundas valley it has been pierced to the depth of 78 feet (60 of which are below the level of the lake.) I am not certain of its occurrence in the upper part of the Dundas valley. South of Brantford, Professor Bell estimates that it must have a thickness of 70 feet, but in Walpole, some miles east of Brantford, the corniferous limestone comes generally to within a few feet of the surface, whose soil is more or less of a clayey character, filled with fragments of corniferous limestone (richly fossiliferous), brought to the surface by frost. This clay also occurs largely about Lake Erie.

The Leda clay of the St. Lawrence valley was more or less denuded before the deposition of the Saxicava sand. So also the surface of the Érie clay was water worn or denuded by subaërial actions. It is then overlaid (often unconformably) by the *Saugeen clay*, which is brownish, in very thin beds (one inch, often separated by sand or gravel, or deposited with intercalated beds of sand. This clay forms a heavy soil. In the neighborhood of the Niagara river and elsewhere it contains fresh-water shells. In the region about the western end of Lake Ontario, much of the country is covered with this clay, or where it is removed by Erie clay. But in the localities immediately in the vicinity of the Niagara escarpment, and often in the Dundas valley, we have the soils formed from the more modern ruins of the Silurian rocks.

In noticing the occurrence of the general deposits in Canada, the boulder clay of the St. Lawrence appears to be wanting in the western portion of the Province of Ontario. The Erie clay, containing boulders, and also angular fragments in part, has been provisionally assigned as the equivalent of both the Boulder and Leda clays of the St. Lawrence valley. The Boulder clay is unstratified (or there are only very few feeble indications of stratification), while the Erie clay is always stratified, showing different conditions of deposits. Yet the Erie clay generally rests on the striated Palæozic rocks in Western Ontario.

In the Dundas valley there is a deposit older than the terraces (for terraces and sea-beaches occur above it), and possibly older than the Erie clay, unless we consider this a higher portion of it,

but which seems scarcely possible as it is thoroughly unstratified, filled with angular fragments of Niagara limestones and constituting a true

Till.—This forms a possible equivalent for the Boulder clay of the St. Lawrence valley. Principal Dawson remarks that the Boulder clay, as far as it is a marine deposit, is older on higher levels than on the lower. Now, we find that the western part of the Dundas valley is made up of great hills and valleys often in the form of *roches moutonnées*, formed largely by the modern denudation of the streams. Sometimes these hills are cut down to a depth of nearly 150 feet. Sections of several parallel ranges may be seen by crossing the country from Ancaster to the G. W. Railway, about two miles east of Copetown. The escarpments at these two places are about 500 feet above Lake Ontario, whilst the beds of some of the valleys (as, for example, near the "sulphur springs") is not more than 240 feet above the same water-level. In this Till, as exposed at the base of the hills, cut away in road-making, I saw only fragments of Niagara limestones, mostly of such thin slabs as the upper layers of the Silurian rocks at Dundas afford; and these stones make up a large percentage of the whole mass of the bases of the hills. Again, it is possible that these unstratified deposits extend down to the Palæozoic rocks beneath, which may be absent for a great depth below the level of Lake Ontario, as they are in the centre of the Dundas valley, more than two miles from the nearest portion of the escarpment. It is only after passing the flanks of these hills, farther eastward, that we find the Erie clay. Some of these hillocks near their summits have old beaches, others capped with clays. Their summits are mostly composed of clays of the Saugeen equivalent or of alluvium. The source of this Till is the ruins of the Niagara formation, and could have been derived from the upper beds of the rocks of that age, which occur on the summit of the escarpment both at Dundas and Ancaster.

Dr. Dawson has shown that the Boulder clays of Eastern Canada were deposited beneath water and contain remains (though not abundant) of Arctic animals. The marine deposit does not extend westward of the outlet of Lake Ontario, but beyond this meridian the Erie stratified clay, resting on glaciated rocks (gene rally), appears to occupy its place, and is often deposited at levels below the lake surface. However, there is (outside of the Dundas valley), at least one place where a few feet of Boulder clay

may be seen—at the Garrison Commons, just west of Toronto, where the stiff clay contains angular fragments and slabs of shales and harder rocks of the Hudson river formation, together with well-rounded and scratched Laurentian boulders.

The Erie Clay in the Dundas Valley, is essentially of moderately deep-water origin, with only the upper portion of the deposit exposed, and rather free from pebbles. An interesting characteristic of this clay is that it burns to form buff-colored bricks (popularly white bricks), while the overlying clay burns to red bricks (Dr. Bell). It is finely stratified with frequently thin seams of sand. In the Dundas valley, the best exposures are on the sides of the branch of the Dundas marsh, which passes up to Beasley's hollow, west of Hamilton. It is especially well shown along the side of the marsh between the Protestant and Catholic cemeteries. There is here an exposure about 30 feet thick. A considerable portion of the terrace which extends from Dundas to Hamilton, at a height of about 70 feet above the lake, has its margin, bordering on the Dundas marsh, underlaid by Erie clay for about the lower 30 feet of exposure. The upper portion of the terrace is made up of a highly arenaceous clay of yellowish brown color, resting unconformably on the surface of the Erie clay, which had been denuded, and in places removed by streams before the deposition of the clay, which when wet resembles a bed of sand in strata from one to three inches thick. This latter clay is probably the representative of the *Saugeen clays*, and is best shown in section along the Hamilton and Dundas street railway. An unconformable junction is exposed just near the "basin" of the Desjardins canal at Dundas. This latter clay forms the loamy soil of one of the finest pieces of farming land in Canada. At the cutting of the Hamilton and Dundas railway, between the Half Way house and marsh, there is associated with the latter deposit a bed of very fine gravel where the pebbles are less than an inch in diameter. This may possibly be of more recent origin. In Beasley's hollow, near Ainsley wood, these clays rest on the Medina shale, and are represented by only a few feet exposed. According to Dr. Bell (as we have noticed before), the Erie clays extend to at least 60 feet below the surface of Lake Ontario, in the Dundas valley. To what depth it extends I cannot say, but it is underlaid by a Till to a depth of about 227 feet below the lake, near the margin of the ancient valley described in former pages. The "*Brown clays*" are also exposed on the northern

side of the Dundas valley, on the terrace, at 90 feet above the water, on which the Dundas cemetery is situated.

Whilst the Erie clays extend to a considerable height above the lake on the borders of the marsh, they do not reach much higher than the water level at Burlington Heights. This fact has a bearing on the study of the Heights themselves.

Between the Dundas valley and the Grand river (that is, in the western part of the township of Ancaster and the adjacent portions of Brant), the country is generally overlaid by a brownish clay, often loamy, remarkably free from stones, and the equivalent (on the surface) of the Saugeen clays. Prof. Wilkins has observed this "brown clay" in stratified beds along the Fairchild's creek.

The Forest bed of Ohio, represented in Canada by logs and stumps, in the brown clays, at Toronto and elsewhere (Hind), marks the period of elevation of land during which the Erie and Leda clays were denuded before the deposition of the Saugeen arenaceous clays and Saxicava sand (of the St. Lawrence valley).

VIII.—STATEMENT OF THE GLACIAL AND ICEBERG THEORIES.

Before considering further the Post Pliocene deposits which occur in the "region about the western end of Lake Ontario," let us briefly examine the two theories that are given in explanation of their origin. It is not my purpose to enter details except those that bear on the explanation of the deposits in the region of study.

The Glacial Theory.—During the later Tertiary days the continent stood at least several hundred feet above its present altitude, probably at the time of the advent of the "great ice age." The two theories—the Glacial or Glacier, and the Iceberg or Floating Ice—differ essentially in the earlier part of the epoch. The former of these theories (or hypotheses) seeks to prove the continuing elevation of the continent after the close of the Pliocene epoch proper; that a great continental ice-sheet capped the northern portion of America, and reached in some instances as far of the 39th parallel of latitude; that the old rivers flowing southward had a greater pitch than at present, and the waters from the melting glaciers running down the elevated old river channels in a southerly direction (and also making new ones), scooped out most of the basins now buried to a depth often several hundred feet below their modern representatives, or the pre-

sent surface of the land where the ancient valleys are entirely obscured. At the same time the erosive effects were obscured by the stones and *débris* deposited by the melting glacier, being transported by the waters rushing down the steep pitch of the river beds. With an increased elevation of the land, the continent would be more elevated to the northward, which would still further increase the velocity of the waters flowing southward, and retard or altogether stop those flowing northward. Other excavating effects would be produced by the glaciers shoving forward the decomposed rock beneath themselves. The existing valleys would to a greater or less degree determine the direction of the glacier itself. These glaciers, laden with stones and *débris*, moving over the land would naturally plane off the rocks below them, and the stones and sand contained in the ice would produce their striated and polished surfaces. The glaciers would transport the local material by the thrusts; and the rocks and other contained *débris* derived from the source of the glacier itself would be deposited as it melted, thus producing terminal (and also lateral) moraines. In order that the glacier could move southward it is not necessary that the surface of the land should have any slope, for if the ice were sufficiently deep, the weight to the northward or towards its source, would cause it to flow like a mass of apparently solid pitch, which when piled up is constantly seeking a lower level. Croll has calculated that the ice could flow if the surface stood at half of one degree above thé ocean level. The terminal moraines produced would tend to dam the waters beneath the glaciers caused by their melting.

After the erosion by glaciers (and the striations of the surfaces of the rocks) was accomplished the continent began to be depressed, and the subsidence went on until the land was more than 500 feet below the present altitude. (But we will subsequently see that the depression continued till a submergence of 1800 feet at least, or perhaps several times that depression was attained). This subsidence and also the previous damming of lake and river basins produced immense inland lakes beneath the continental glaciers, or floating icebergs derived from them. As the glaciers melted, the transported *débris* contained in them was deposited in an unstratified manner on the land, or where it fell into water it was partly stratified. This period of the glacier constitutes the Diluvian era or Lower Champlain epoch. The preceding period of elevated continent forms the period of glacial drift. But the

greater part of the unstratified drift, as stated by Prof. Dana, was deposited in the Lower Champlain epoch.

The boulder clay of the St. Lawrence was deposited in both the Glacial Drift and Lower Champlain epochs (of Dana), and a portion of the Erie clay of the region of the great lakes in the latter epoch, if not in that of the Glacial Drift of the present classification. But as the Erie clay is stratified, it could not have been deposited in the epoch of the Glacial Drift according to the theory of an elevated continent. After the Diluvian or Lower Champlain epoch, the waters continued to be deep, but with much floating ice, bearing erratics. This constitutes Dana's Alluvian or "Upper Champlain era" of stratified clays and gravels.

At the same time the Leda clay (stratified by water and of marine origin) and the upper portion of the Erie clay (stratified and of fresh water origin) were deposited. Then the seas became shallow from the elevation of the continent; and, finally, in some places a forest growth appeared on the uplifted land Again, there was a subsidence on the production of a glacial lake, and there were then deposited the upper beds of Dana's "Alluvian era," corresponding to the Saxicava marine sands of the St. Lawrence, and the Saugeen clays of Ontario. There was still boulder-laden floating ice. As the continent was again rising, or the waters of the glacial lake subsiding, the elevated terraces or beaches were made at heights from 1700 feet to the sea level in the region of the lower lakes. These terraces will be described in succeeding pages. This elevating process continued until the continent stood at perhaps 200 feet above the present altitude, marking an epoch known in Europe as the Reindeer or Second Glacial period. Then came the subsidence which brought the continent to the present general level with the modern deposits.

The Iceberg Theory.—The Iceberg Theory differs essentially in the beginning and early days of the "Great Ice Age."

According to this theory the old channels now buried were produced in days before the advent of the Glacial period, by the erosive action of the atmosphere, and pre-existing rivers, when the continent was at a higher elevation, and date back to very ancient geological times. At the commencement of the Ice Age the continents were subsiding until depressed much below the present sea-level. At the same time glaciers were accumulating in the northern highlands, and even farther south-

ward, where there were any elevated peaks or table lands. These highlands were constantly sending off icebergs which, breaking loose, were borne southward by the oceanic or lacustrine currents, and carrying with them their loads of stones and *débris* from the region of their foundation. The striations of the rock surfaces in continental areas, remote from glacial-producing mountains, (or hills perhaps) was accomplished by the stranding of the bergs in the comparatively shallow basins. This action is shown to-day on the coast of Labrador and Greenland. At the same time the melting bergs were depositing their loads as boulder clay. The iceberg theory accounts for the boulder clay of the St. Lawrence and the stratified Erie clay (with boulders) of the lake region, both dating back not only to Dana's Champlain epoch, but also to the epoch of his Glacial Drift.

There is no material difference in the explanations of the origin of the middle and later deposits of the Glacial period, as rendered by the more liberal view of the glacial and iceberg hypotheses, both recognizing the subaqueous origin of the Leda clay, the upper part of the Erie and other stratified clays, the Saxicava and other sands and beaches. However, according to the glacial theory, much of the stratification of the deposits took place in lakes and rivers dammed up by the glacier itself, without so great a subsidence of the continent as the extreme iceberg theorists would have.

Distribution of the Northern Drift.—Let us now examine what evidence, aiding the elucidation of the history of the Great Ice Age, can be derived from the study of the region of Lake Ontario. In doing this, however, it will be necessary to go somewhat out of the locality of our immediate study.

The so-called ice-cap of the northern hemisphere was confined principally to the region of the North Atlantic Ocean. In America, Professor Whitney states, as the result of extended observation, that there is no evidence of an ice age at low levels along the Pacific Coast, except along the sea, at such elevations as could be glaciated by floating ice during a slight subsidence along the coast of Vancouver's island, on an adjacent coast of the mainland. The southern limit of the northern drift on the eastern side of the Rocky Mountains may be approximately designated by a line drawn from the head waters of the Saskatchewan river to the mouth of the Missouri river, thence to the centre of Ohio, through Pennsylvania and New York, to northern New Jersey.

In Europe the northern drift descended from the Scandinavian mountains towards Central Russia. It did not cover Eastern Europe, nor any portion of Asia, but in the eastern hemisphere it was confined to the north Atlantic.

The greatest development of the deposits of the Ice Age is adjacent to where there would have been the greatest precipitation of moisture. We see to-day that much of Greenland is covered with glaciers, but Messrs. Fielden and Rance (of the Arctic Expedition of 1875-76) observed the paucity of glaciers in Northern Greenland, and that neither there nor in Grinnell's Land, north of about lat. 80° 20' were icebergs (derived from glaciers) met with, but all the ice was considered as floeberg ice- Capt. Nares explains the difference between the ordinary floe and Polar sea ice. The former is only a few feet thick, and meeting with obstacles, it sometimes gets piled up 40 feet or more in height, while the latter is 80 or 100 feet thick. and simply lifts any obstacle in its way. Now, our glacial friends, in referring to the "American Ice Caps" or sheet, can only refer to the region covered by northern drift before roughly outlined, which did not even cover Alaska. It must also be remembered that any such ice cap, as they require, would be lessening in thickness as it receded from the eastern margin of the continent. with its Laurentian and Appalachian Chains of mountains, to cut off the Atlantic moisture, as we have just seen with regard to the northern coast of Greenland. We are told that the drift is found in the White Mountains at an elevation of more than 6200 feet on the top of Mount Washington, with erratics (belonging to a lower topographical level) on the summit of the mountain, and that all this *débris* was pushed up by a glacier. Whilst there seems no doubt of the existence of glaciers in the White Mountain regions, it seems really too hypothetical to place a glacier in the White Mountains at the high elevation, that in moving would push up *débris* even 500 feet from the summit of the highest adjacent mountains.

Thickness of Ice Cap.—When Professor Agassiz announced his glacier hypotheses, requiring a continental glacier to overtop by 2,000 feet, the highest peaks of Mount Desert Island (which are in the same latitude as Mount Washington, with an elevation of more than 1500 feet) and project to Long Island Sound—Professor Leslie calculated "the height of the snow mass necessary for producing the supposed motion of

this glacier at 20,000 feet, at the pole) and the abstraction of that amount of water from the sea would lower the sea-level over the whole globe about 600 feet. The snow cap necessary to lift drift material over Mount Washington would so much exceed this thickness as to increase the improbability. Nor does it seem possible that any local glacier in the White Mountains could, even if it had a sufficient thickness to produce its own flow, lift drift materials several hundred feet higher than the place whence they came, and not sheer off on the lower ice and pass around the high peaks—a constant requirement of the glacier hypothesis.

It is not my purpose here to attempt to discuss the ice cap in the White Mountain regions. Yet it is necessary to refer to this region on account of the great elevation of drift material, in looking out the causes of the drift in the region of Lake Ontario. The local evidence of moraine-formed dams does not seem sufficient to counteract the seeming impossibility above pointed out.

Transportation by Coast Ice.—The floating ice theory here answers much better than that of the glacier, for on the continent sinking the ruins of the hills of lower levels could be carried upward by the action of coast or pan ice of successive years, which along the Restigouche and St. Lawrence rivers has been known to move enormous blocks of rock to a considerable distance in a single season. The great precipitation of snow about the North Atlantic, along the ranges of American mountains bordering it, would tend to depress the north-eastern portions of the continent more than either those to the southward or westward. This depression was nearly 2,000 feet, at least in the later Terrace epoch of the Ice Age, beyend the Western End of Lake Ontario. In the mountain regions of the Pacific coast the evidence of a subsidence to more than 4,000 feet is apparent.

At the northern end of Skaneateles Lake in New York we find, at an elevation of 860 feet above the sea, Corniferous limestones, which belong to rock beds *in situ* at only lower levels to the northward. These apparently were lifted upward by floating ice during the subsidence of the region. Again, at the Western End of Lake Ontario, we find great quantities of water-worn pebbles, whose original rock lies thirty or forty miles away, but at only lower topographical levels, except a great distance away.

Terminal Moraine Hypothesis.—Another evidence strongly

adduced by the glacialists, in support of the continental glacier, is the so-called terminal moraine, represented in Canadian North-West Territories and North-Western States by those ridges of drift hills, known as Coteau de Missouri, Coteau des Prairies, Kettle Moranies (of Wisconsin), the ridges about the southern end of Lake Michigan, across Ohio and Pennsylvania, the range of drift hills of New Jersey, and the drift hills of Long Island.

The whole of Long Island is composed of stratified drift (considered by Prof. Dana to have been deposited by the glacier ice water). Several, at least, of the so-called moraines of New York and Ohio, represented by the ridges south of Lakes Ontario and Erie, are evidently old water margins. The ridges south and west of Lake Michigan, constituing the so-called Kettle Moraines, are rudely stratified, according to Dr. E. Andrews, of Chicago. And the described structure of the North-western Coteau, containing so much gravel and boulders, even if the greater protion be not stratified, together with the flat country to the north and north-east (whence much drift material from the lower level of the valley of Lake Winnipeg was transported westward and southward to much higher altitudes) makes us look with doubt upon much that has been written about these regions, in support of the favorite Ice-Sheet theory.

With equal propriety could we call the Artemisia gravel and the Oak ridges (to be referred to under Terraces) as terminal moraines of the Province of Ontario; (at least the former of these ridges rises to an elevation little inferior to the Coteau des Prairies). These highest and most distant ridges, surrounding the great lake basins containing unstratified boulder clay would be just what one would expect to find where the laden ice, from northern highlands, after crossing this island sea, became stranded, and finally melted as the old hills were sinking to, or rising from the sea.

However, it is not my purpose to discuss the subject of the Glacial Geology of America, but only to describe some of the surface features in the "Region About the Western End of Lake Ontarion," and see what lessons can be derived therefrom.

Agents of Glaciation.—Glaciation of rock surfaces can be produced by the action of the glaciers containing stones, or by that of floating ice shod with rocky matter. Ice of itself, unless frozen to its bed has no important erosive action. In fact, the principal erosion beneath a glacier is produced by the action of

running water, hurling along the *débris* from the melting glacier. Again glaciers derive their principal loads of *débris* from overhanging rocks, which would seldom appear above a grand continental glacier. Ice with even little or no foreign material may polish surfaces (not seorify) when hurled by the action of waves and tide, as seen by Prof. H. Y. Hind, on the coast of Labrador, where the hard rocks have been polished for several hundred feet above tide, during the time that that portion of the continent has been rising.

From various Arctic expeditions, we learn about the enormous quantity of detritus which is annually removed by the floe or coast ice, though only half a dozen feet thick. This ice gets piled up, and by the action of wind and tide abrades the shore to an elevation of 30 feet or more.

Our American geologists of the glacial school seem unwilling to attribute the scorifying power to floating ice, which becomes temporarily stranded. Even the grinding of the contained stones in floating ice stranded at low tide, in the trough of waves of a rough sea, acting during long periods of time, would produce great effects. Fairly considering the question, the ice-marked surfaces of the region of our study tell us but little in favor of either the glacier or the iceberg hypothesis. Even the south-eastern striations in the highland counties of Ontario (characterized in part by the Artemesia gravel) at most could only have been produced by local glaciers discharging small bergs into the Ontario sea, whose general currents were drifting to the south-westward.

Any continental glacier passing over the region of our study must have filled the basin of the western end of Lake Ontario and the ancient Dundas valley (more than two miles wide, and from 750 to 1000 feet deep) else the Niagara escarpment of preglacial date facing the lake would have been planed off by the eroding force which struck it obliquely without having the direction of the force changed (except in the valley itself) for we find the summit angles sharp. Nor has this sharpness been subsequently produced by frost action as indicated by the talus at the base of the slopes. The ancient Dundas valley, as has been pointed out, brings additional proof, that the region was not excavated by glacial action. Even the removal of the upper hundred feet of the escarpment on the western side of Glen Spencer, which most nearly resembles glacial action, was not effected by ice-action but

by subäerial agencies, which removed the upper surfaces of the narrow spur of rocks separating this glen and Glen Webster from the *cañon* of the Dundas valley.

It seems impossible that in the region of the lakes any great moving glacier did exist, which measured from a depth of what is now 500 feet below the sea to a height sufficiently great to push forward the *débris* from that depth to an elevation of from 1000 to 2000 feet or more over the highlands of New York, Pennsylvania and Ohio. The configuration of the region would not favor such a condition of ice—for the mountains of Labrador, of Quebec, and of New England, assisted by those of New York and Pennsylvania, together with the highlands of Ohio, would have necessarily cut off the moisture and prevented the precipitation on the interior of the continent, as we to-day see in Hall's basin and the Polar sea in the far north.

Origin of Boulder Clay.—Boulder clay may be produced by floating ice as well as by glaciers. Prof. H. Y. Hind has observed its formation at the present time on the coast of Labrador, by the action of pan ice. In Arctic regions the contortion of submarine mud by the jamming of stranding masses of the thick ice of the polar seas, has been observed to produce such effects as are often attributed to glaciers, and could quite as easily by pushing along the softened mud produce the so-called ground moraine, as a glacier.

Thickness of Drift.—Throughout the Province of Ontario, the average thickness of the Post Pliocene deposits is less than 50 feet, excepting in buried channels and along certain ridges. As exhibited in many sections exposed to the bed rock and in many bore holes, it seems that the drift is nearly everywhere stratified, and the unstratified drift is the exception outside of buried channels.

Glacial Lake (Hypothetical).—According to the glacial theory, after the recession of the glacier-ice which scooped out and filled the great lake basins, and moved over the hills (from 1500 to 2500 feet above their deepest beds) to the south, there was produced a great glacial lake by the closing of the outlets with ice, and in this lake the stratified drift was deposited. We have already shown that the lakes are not of glacier origin. If it had been possible for the ice to have been pushed up and over the great elevations referred to, yet it seems highly improbable, that a remnant of floating ice could have dammed up not only the

lower outlets to the lacustrine sea, but also raised many of the lower ridges to the south by an ice barrier sufficient to prevent the overflow of its waters. As remarked by Prof. Dana, no moraines bear evidence of such a dam at 1000 feet above the sea. In the Province of Ontario the stratified drift in very many places is at a much higher level than long stretches of the barrier ranges to the south. Moreover, at the time when part of these stratified deposits were being produced the sea contained little or no floating ice wherewith to close the outlets, much less to increase heights of the barriers.

Consideration of Changes of Level and Deposit of Boulder and other Clays.—According to the glacial theory the continent stood at a much higher elevation in the ice age than at the present time, yet it does not demand any very great changes of level. So also in the above remarks, the subject of local oscillations has not been an element of consideration, yet great changes of level did take place. The marine boulder drift of the St. Lawrence valley, containing Arctic shells, reaches an elevation of over 500 feet, irrespective of higher and more modern terraces. Also the coast of Labrador has been known to have risen to great heights since the ice age. Prof. Dana remarks that the continent was more elevated to the northward than the southward.

During the great accumulation of ice along the mountains of Labrador, Quebec, New England, New York, etc., and in fact around the north Atlantic, there would have been a relative sinking of the continent arising from the change of the centre of gravity of the earth. The subsidence would begin along the Atlantic coast and extend westward. We know that the large deposits of Boulder clay in the St. Lawrence valley are marine and deposited beneath water. However, on moving up the St. Lawrence valley the evidences of the marine character gradually disappear as the Arctic shells cannot be traced to the western deposits. Nor do any of the marine Port Pliocene deposits pass westward of the east end of the valley of Lake Ontario (whose elevation is 247 feet above mean tide). The unimportance of the Boulder clay farther west in Ontario, or more frequently its entire absence, with Erie stratified clay containing a few boulders, especially near its base, resting on striated rocks, points to the fact that the ice age and the continental subsidence began earlier to the northeastward than it began in the valley of Lake Ontario and the region to the west of it. This being the case, we have an explan-

ation for the change of character of the drift deposits from the marine "Boulder clay" of the St. Lawrence valley to that of the lower boulder-bearing (probably) fresh-water Erie stratified clays, for the conditions favorable to the deposition of the topographically lower Boulder clay would exist for a longer period than those of the Erie clay having been begun and partly completed before the formation of the latter clay. The increasing accumulation of ice about the barrier hills would close the St. Lawrence valley to marine currents, and cut off much of the precipitation of moisture from the interior basin, leaving it freer to the action of coast and berg ice from the adjacent mountains.

Higher than the Niagara escarpment, or 750 feet above the sea, the country beyond the western end of Lake Ontario affords very little Boulder clay except in old buried valleys.

The greater part of Erie clay appears to be contemporary with the later deposited portions of the Boulder clay and with the Leda clay of the St. Lawrence valley during a time of contracted ice sheets, when the sea was again making inroads on the continent. The Erie clay occurs at elevations of 1000 feet in the Province of Ontario.

The Unproven Character of the Glacial Hypothesis.—After careful study of the subject of the drift deposits in the lake region, and after reading an immense amount of literature on the subject of glacial geology of America, wherein one finds many intererest-ing discoveries, yet an enormous amount of dogmatism unworthy of scientific observers, there is but one conclusion that I can arrive at—namely, that the glacial theory is not applicable to the explanation of the physical features of the lake region, either of the moulding of the country, as considered under the origin of the lakes or of the glaciation, or of the drift deposits of the Ontario peninsula. It is true that a great theory cannot be considered either as proven or disproven by limited observation, and that is all which this paper purports be—not a consideration of the whole subject, even as far as America is concerned, much less Europe.

Events after the Close of the Epoch of Erie Clay.—After the period of the deposit of stratified Erie clay, there appears to have been an elevation of the land, for in Ohio and other States it is succeeded by a forest growth and denudation of the surface of the country.

During this time in Ontario the surface of the Erie clay was

denuded, so that the succeeding Saugeen clays lie on it uniformly. The valley of the Dundas marsh and Burlington bay, besides such tributary streams as the Cold Spring creek were excavated in it. The Cold Spring creek excavated a channel in the Erie clay a few hundred feet wide (as seen along the Hamilton and Dundas street railway, which descends to the marsh along this creek), before the deposition of the arenaceous clay. In fact, a considerable portion of the Dundas valley was reëxcavated by the large streams of this time. It was during this period of denudation that the forest trees were flourishing which are found under the clays and sands about the city of Toronto and in the Scarboro Heights. Then came the subsidence with its deposit of Saugeen "brown clay" (described before), which covers so much of the surface of the Dundas valley and in fact a great portion of the Province of Ontario. During this deposit there appears to have been little or no floating ice in the region of study, as there is a remarkable absence of erratics. The erratics belong to later date.

The Scarboro Heights—East of Toronto. Mr. George Jennings Hinde has written an interesting paper.* Unfortunately

* Canadian Journal. 1877.

the author is a member of the more advanced school of glacial thought. Over the stratified clays and sands there is a deposit of what Mr. Hinde calls Till. This fills a valley of a stream scooped out by a probably interglacial stream. However, the writer considers it (which he figures) as a glacial hollow (like our lakes) filled up. From the evidence as laid down, it is conspicuously an old water course, and there is no evidence given to show its glacial origin any more than there is evidence of the glacier excavation of the lakes. This so-called Till is composed of far drifted Trenton limestones and Utica slates. The most rational description of the presence of this "Till." is its derivation by coast ice from the Trenton and Utica rocks which formed the shores to the north and east.

Closing Remarks on the Glacial Theory.—In the Dundas valley there are a number of sheep backs or *roches moutonniés*. The summits of these hills, at least, belong to the Terrace epoch, and may be easily explained by the denudation by streams, owing to the peculiar features of the country, which will again be noticed.

The Cause of the Arctic Winter is a question outside of this short descriptive study. However, the theory of the "secular

changes of climate," arising primarily from the eccentricity of the earth's orbit, as proposed by Mr. James Croll and accepted by Mr. James Geikie in the two admirable works, "Climate and Time" and "Great Ice Age," seems the most feasible; and to those works I refer any enquiring readers. With regard to the *Ice Age of Scotland* and north of England Mr. Geike makes out a much better case than our American glacial friends. It must be remembered that Scotland is in the lattitude of from the middle to the northern part of Labrador, and were the Gulf Stream to change its course, and with a little increase in quantity of precipitation and fog, to-day, it would again become a glacial region. The drift which occurs in the lake regions of America resembles more nearly that of central Europe than that of Scotland and Scandinavia, where the evidences of glacial action are more apparent than on the continent. At the present time only glaciers in the far north discharge icebergs into the sea, yet these are driven farther southward than the extreme limit of southern drift in America. It must be remembered that these bergs come from a latitude not much farther north than the Scottish islands.

Therefore, the American reader must not be unintentionally led astray. On this continent there are but few writers who are unbiassed, and it is somewhat uncommon for a student to meet with a judicial production as geology has not yet produced the great mind who has been able to decipher all the valuable hierogliphics of surface geology on this continent. A portion of the partizan writings is unavoidable but very many more are unworthy productions of the servile obedience to the memory of the distinguished founders of the glacial theory, who never exacted the homage bestowed by some of their disciples, attributing to glaciers any sort of features whose origin is somewhat obscure.

IX.—TERRACES AND BEACHES.

Overlying the "Brown clays," or where these are absent, the blue Erie clays, there is a considerable number of terraces and beaches, whose remains are to be seen at the western end of Lake Ontario. Especially is this the case in the Dundas valley; but even here the majority have been more or less removed by subsequent denudation, so that at the higher levels there only remains an occasional hill capped with stratified sand or gravel, or small fragments of the isolated beaches skirting the Niagara escarpment.

High Beach near Waterdown.—Beginning with the beaches at the highest altitudes, about the immediate vicinity of Lake Ontario, there is an extensive deposit of sand and fine gravel near the village of Waterdown, on the top of the Niagara escarpment, at an elevation of 500 feet (estimated) above the lake.

High Beach near Ancaster.—On ascending the Dundas valley to the watersbed between it and the Grand river, about a mile west of Ancaster village, there are several deposits of stratified sand and fine gravel on the summits or sides of the hills at an elevation of 440 feet (estimated) above the lake. At one of the exposures of these deposits, there is an oblique bedding dipping 23 degrees to the south-eastward. False bedding is very common, These beaches are more or less composed of well water-worn pebbles of the Hudson river formation. At the same elevation but south of the Grand river, near Seneca village, there is another gravel deposit.

Highest Beach at Dundas.—Our next beach is the small remains of a terrace found at the height of 335 feet (levelled) above the lake, on both sides of the mouth of Glen Spencer. The elevation was levelled on the eastern side of the Glen. As only a very small fragment remains, fringing the older rocks, it is possible that it may have formerly extended somewhat higher. This is the *beach* in Dr. Bell's report to the Canadian Geological Survey, estimated at 318 feet. This deposit consists of rounded pebbles of the Niagara limestone, with which are associated pebbles of the Hudson river period and a few others of crystalline rocks. Much of this deposit has been artificially removed in making the railway embankment across Glen Spencer, near the Dundas station.

Another Beach at Ancaster is found on the sides of one of those so-called "sheep's back" northward from Ancaster. It is probably at the same elevation as the last terrace described at Dundas (335 to 360 feet above the lake). It is composed of very fine gravel and sand, derived more or less from both Hudson river and Niagara rocks, together with many angular beds of Niagara limestones and shales. The exposure of this deposit is on the south side of a spur or ridge which rises nearly 100 feet higher. As the ridge is covered with soil it is only at the pits where the gravel has been removed for road purposes that sections can be seen. Above the gravels there is a deposit of clay containing many angular slabs of Niagara limestones and shales.

More careful examination is necessary to determine whether this "boulder clay" is older or newer than the gravel which flanks the hill, for in some places it appears to overlie the gravel, but it may have been derived by land-slides from the higher level of the steep hills. In this region, north-west of Ancaster the hills, flanked with beaches, are separated by ravines, often 100 feet deep, with beds not more than 240 feet above Lake Ontario.

Terraces at the level of 261–224 *feet*—On the hills adjacent to the beaches described, near the outlet of Glen Spencer, there is a terrace with a rolling surface (on which is the Roman Catholic cemetery) of sandy material, having a height of 261 feet above the lake. The side of the same hill, at a height of 224 feet, shows stratified sand and fine gravel, which is exposed for fifty or sixty feet almost vertically. This is on the northern side of the town about three-fourths of a mile eastward of the railway station. The sand contains layers of fine gravel, much of which is evidently of the Hudson river formation.

Terrace at a Level of 180 *feet.*—One of the most perfect of the "sheep's back" occurs on the southern side of Dundas, within the corporation. This is situated behind "Gartshores dam" and has a height of 180 feet (levelled). A gravel pit has been opened on the upper portion and stratified gravel has been exposed for a depth of 30 feet. The lower portion of the hill near the dam is composed of blue clay, but a section of the whole hill has not been laid open. Most of the gravel is fine, but it contains a considerable number of stones eight or ten inches in diameter, with a few slabs as much as one and a half feet in diameter. These larger stones are mostly composed of Niagara dolomites and are semi-angular. I did not find Hudson river fossils in the pebbles, but am of the opinion that much of the gravel is composed of these rocks.

The Great Terrace at 116 *feet above Lake Ontario* is the most widely spread of all the ancient beaches. At the Dundas valley it occurs on the northern side of the town and includes the higher portions of the terrace on which the cemetery is situated. Here the surface is composed of brown clay, underlaid by a sort of quicksand, which is probably Saugeen clay.

The terraces and beaches at about this height are seen on the northern side of Burlington bay and farther eastward south of the lake. The Burlington heights (108 feet) belong to this system. Eastward from these heights it runs diagonally with a

slight curve through the city of Hamilton until it abuts against the foot of the mountain, near the head of John street. Again, in the vicinity of the city reservoir (at the same height) it commences its course again and extends eastward. Occasionally where the older deposits are higher, or the escarpment sends out jutting ridges this terrace suddenly stops, but beyond, where the same contour line is met, the beach is found. A terrace northward of Toronto also occurs at a height of 108–114 feet above the lake, and near Burlington at 118 feet. This terrace formed an old beach, as is shown by the sorted and stratified sands and gravels everywhere in the localities mentioned except on the northern side of Dundas, or on the south-western side of the Burlington heights. The pebbles of this beach contain a few Laurentian rocks, but with this exception the whole of the mass is made up of ruins of the rock of the Hudson river epoch. These pebbles are well rounded and usually not more than six inches in diameter, although in some places there are large rounded slabs from one to two feet long. I have closely examined these deposits and have never seen any pebbles that appeared to be of the Niagara formation. Though all the stones are not fossiliferous (some arenaceous and some calcareous), yet a very large number show the characteristic Hudson river fossils. In this terrace, at Burlington heights, remains of the mammoth wapiti and beaver have been found.

Terrace at the Level of 70 *feet.*—Our next terrace is most apparent in the Dundas valley, although occurring on the northern side of the lake, and less conspicuously or more gently sloping in Hamilton and eastward. This terrace occupies most of the country beneath the escarpment from Beasley's hollow, at Hamilton, westward, to near Dundas. Its northern side slopes abruptly to the southern margin of the Dundas marsh. There is also a terrace on the northern side of the town of Dundas, at the same height (in the region of Victoria street and the driving park). The central portion of the city of Hamilton is on the same terrace which, however, more gradually slopes to the lake level than at Dundas. The height of this terrace is 70 feet. It is composed below (where exposed) of blue (Erie) stratified clay. Above, it is composed of a yellowish brown clay (the Saugeen equivalent) which is inconspicuously stratified, but in the cuttings of the Hamilton and Dundas railway, we have seen that the sand washes out and shows the stratification. Along the

same railway cutting, near its northern margin, there is a bed of very fine gravel whose pebbles resemble those of Hudson river formation, but no fossil remains prove positively that origin. As the exposure of the limits of this gravel is not made, I cannot say certainly whether it is the same age or not, but am inclined to regard it as a marginal deposit on the side of the hill facing the Dundas marsh at a height of about 45 feet.

Beach at the Level of 15 *feet.*—Of our next beach only a small portion remains. It has a height of about 15 feet above the Dundas marsh on the side of Beasley's hollow, just below the Catholic cemetery, at Hamilton. It is composed of shell marl made up of masses of broken shells, whose components will be subsequently noticed, under modern deposits.

Present Lake Beach.—Our lowest and last beach is that of the present lake level, and extends a few feet above its present shores. The components of this beach from Toronto to Hamilton and eastward to Grimsby, Beamsville and Niagara river are of Hudson river pebbles with a few Laurentian stones. In the region of Hamilton the pebbles at the lake level in part have been derived from the older beach of the same material at the level of 116 feet. But the Burlington beach, separating the waters of the bay of tha same name from Lake Ontario, could not have been derived from these deposits by any agency working at present. The Burlington beach is less than half a mile wide with a mean height of 8 feet and deposited in water about 80 feet deep. The present Burlington beach and the bed of the bay are exactly a counterpart of what was happening when the lower portion of the Dundas valley was submerged and formed a bay, cut off from the lake by what now forms the narrow ridge of Burlington Heights.

Other Beaches in Ontario.—In 1837, Mr. Thomas Roy measured the beaches between Toronto and Lake Simcoe, having the following elevations above Lake Ontario:—110, 210, 282, 310, 346, 402, 422, 592, 558, 526, 682, 734, 764 feet respectively.* Additional gravel beaches occur along the Northern railway at 600 feet, and on descending towards Georgian bay at 520, 388 and 354 feet above Lake Ontario. A still finer series of beaches

* The elevations were copied from the Geology of Canada, where elevations were given above sea; the Geological Survey places Lake Ontario at 232 feet above high tide.

may be seen from Toronto westward along the Toronto, Grey and Bruce railway. The elevations and locations were kindly furnished me by Edmund Wragge, Esq., the chief engineer of the railway. These sand and gravel deposits occur at the following elevations above Lake Ontario:—160, 280, 370, 710, 990, 1340 feet respectively. After passing the summit of the road (1462 feet above Lake Ontario) and descending towards Lake Huron there are gravel beds at 1310 and 1000, and several beds with elevations down to 697 feet above Lake Ontaio. Along the western branch of the road there are also gravel deposits at 1299, 1130, 1050, 870, 850 and 830 feet above Lake Ontario.

Beaches Adjacent to Lakes Superior and Huron.—The "Geology of Canada" contains the following list of beaches adjacent to Lake Superior, near Petits Escrits, at 398, 408, 458, 502, 627, 635 and 699 feet above Lake Ontario. At Owen Sound there are beaches at 120, 150 and 200 feet above Lake Huron, or 466, 496 and 546 feet above Lake Ontario.

Beaches South of Lake Ontario.—Along the Great Western railway, adjacent to the valley of St. David's, (filling a portion of the *cañon* of the interglacial Niagara river) there is a beach at 386 (to about 250) feet above Lake Ontario.

I have not been able to obtain the list of any series of terraces and Ancient beaches in New York State. Prof. Hall places the highest "lake ridge" at 190 feet. I have observed the old beach adjacent to the Seneca lake and at the north end of Skaneatles lake, which reach to an elevation 860 feet above the sea, and have placed the top of this east beach about (613 + 12) 625 feet above Lake Ontario.

Gravel Ridges South-West of Lake Erie, have been observed by Messrs. G. K. Gilbert and Winchell at 490, 386, 408, 350, 220, 195, 165, and 90—65 feet above Lake Erie.

Artemesia Gravel and Oak Ridge.—All the higher beds of stratified sand and gravel along the Toronto, Grey and Bruce railway are within the area of Dr. Bell's *Artemesia gravel*, which forms a slightly curved belt 100 miles long and about 23 miles broad, facing the Ontario valley. The belt extends from near Owen Sound, on Georgian bay, to near the city of Brantford.

Dr. Bell describes the Artemesia gravel as follows:—"This great belt of gravel has a general parallelism with the Niagara escarpment, and follows the highest ground of the peninsula. The materials composing it consist principally of the ruins of the

Guelph formation, on which the greater part of it lies except towards the southern extremity, where the Niagara formation is largely represented. Pebbles of Laurentian and Huronian rocks are everywhere mixed with the others and sometimes form a considerable proportion, while rounded fragments from the harder beds of the Hudson river formation occur locally in some abundance." (Note—These last rocks are obtained from lower levels.) " The gravel is all well rounded and generally coarse. It often constitutes what might properly be called cobble stones, being loose and free from any admixture of clay, and it is distinctly stratified. Well-worn boulders of Guelph, Laurentian and Huronian rocks are disseminated through the whole mass. At Brantford and Mount Forest (?) it overlies blue Erie clay."

TABLE OF ELEVATIONS OF TERRACES, BEACHES AND RIDGES.

The following elevations of terraces and beaches are here tabulated with reference to elevation above mean tide. This, however, can only be approximately done as none of the series is complete. Some of the elevations refer to the highest exposures and others to pits cut into the gravels:—

References of table on opposite page.

a On high lands of Michigan.	*e* Along W. G. and Bruce railway.
b Summit of land.	*f* Along Whitby branch of Midland railway.
c Beach also of this elevation on Mackinac island.	*g* Along Midland railway.
d Adjacent to St. David's valley.	*h* Along T. G. & B. railway.

TABLE OF ELEVATIONS.

At Western end of Lake Ontario. (Spencer.)	Between Toronto and Lake Simcoe. (Roy.)	Along Northern railway from summit to Georgian bay.	Along Toronto, Grey and Bruce railway. (Wragge.) m is on main line. w is on west branch.	Near Owen Sound. (Bell.)	Petits Ecrits, Lake Superior. (Geology of Canada.)	In New York State.	At western end of Lake Erie. (Geology of Ohio.)	Along the Lower St. Lawrence. (Dawson.)
			1,709 (b)		1,700 a			
			1,587 (m)					
			1,557 (m)					
			1,546 (w)					
			1,377 (w)					
			1,367 (m)					
			1,297 (w)					
			1,247 (m)					
			1,237 (m)					
		1,140	1,117 (w)					
			1,097 (w)					
			1,077 (w)					
							1,063 to	
1,011	1,001						959	
							981 to	
981							923	
			957 (m)					
929			944 (m)		946			900
					882			
	873				874	872		
		847	848 e		839 c		793	
	805						768	
		767		793			738	748
747	749	737						
687	(?)			745				
	669			713	705			
	649							
633	d	635			655		663 to	660
582	593	601	617					
	557				645	647	638	
	529					583(?)		
508			527					
to		498	f					
471								505
	457							479
								448
						437 to		
427						432		
	407		401					
						405		
								378
363								
		342	g					
327								325
255								
to								
247								

At a much lower level than the higher or medial portion of the Artemesia gravel ridge which runs nearly north and south; there is another ridge known as the "*Oak Ridge,*" which leaves the Silurian escarpment near Palgrave (on the H. & N. W. railway) at a height of 722 feet above Lake Ontario. It extends eastward to near the "Great Bend" of the Trent river, the summit of the range being about twelve or fourteen miles north of the lake, after passing eastward of Toronto. The Northern railway crosses it at 754 feet, the Toronto and Nipissing at 893 feet, Whitby branch at 781 feet and the Midland railway at 665 feet above Lake Ontario. It is from 200 to 300 feet above the broad trough from Georgian bay to the Bay of Quinté, occupied by Simcoe, Balsam, Rice and other lakes drained by Trent river. The basin of this trough is underlaid by Palæozoic and older rocks. Several small lakes occur on this ridge without apparent outlets. A spur of this ridge runs to Lake Ontario near Scarboro, and forms the "heights," rising 300 feet above the lake. It consists principally of stratified fossiliferous clay and sand with two intercalated beds of boulder-bearing clay. Portions of the "Oak Ridge" eastward of the meridian of Toronto, consist of clay ridges—probably the exposed equivalents of the clay beds of "Scarboro Heights." The highest portion of Oak ridge is only 300 feet above the rocky floor of the trough, which forms the immediate northern margin. We are safe in concluding that the stratified character of the lower portion of the ridge continues downward to the rocky floor on which it lies, or with no important unstratified deposit beneath to constitute it a moraine.

In studying these ridges, especially the Artemesia ridge, we cannot fail to be struck with the similarity of those so-called Kettle Moraines of Wisconsin, Coteau des Pairies and Coteau de Missouri. There is a general parallelism between all these ranges. Even a portion of the Artemesia gravel is nearly as elevated as Coteau des Prairies.

Other high terraces and beaches occur along the St. Lawrence at 900 feet above the sea (Dawson); and in Labrador, at 1000 feet, besides erratics at much higher elevation (Hind).

In Ireland and Wales marine beaches are found at from 1200 to 1400 feet above the sea.

Origin of the Terraces.—As before pointed out, we have no evidence of any general morainic character of the "Oak ridge." On studying the levels of the country covered with Artemesia

gravel, we see simply a high ridge of land with beach markings all the way down from the summit (over 1700 feet above the sea) to an altitude of about 950 feet, surrounded by one succession of old water-margins, indicating the gradual growth by elevation of a rocky or generally rocky island, for the "Artemesia gravel" reposes (as far as I have been able to learn) on hard rocks or stratified clays, except in the old buried channels of tributaries of the ancient Grand river (principally). Surrounding the old island we find in several places rude terraces of about the same altitude, at many miles apart. Yet the waters did not linger as long to form marked terraces as at lower levels. This general deposit in no way partakes of the character of a Scotch kame, even though we considered the "Oak ridge" of that character, as the latter much more nearly resembles one in outline, relative direction and composition than the Artemesia highlands. The whole series of beaches and terraces about Lake Ontario marks the slow elevation of the continent, causing lands at various elevations to be covered somewhat uniformly with the gravel and sand, and again somewhat intermittently, producing well marked terraces. Nor did this subsidence of the waters cease when the present lake level was obtained, as we have a comparatively modern ledge, carved out of the soft Medina rocks near the outlet of the Welland canal, below the surface of the lake and extending downwards for a known depth of more than forty feet. This fact would indicate local oscillation of the margin of the present lake basin.

I fail to comprehend how any glacial lake could have existed when it was producing terraces over all the great lake region at an elevation of what is now 1700 feet above the sea, for the surface of the waters was not covered with any great amount of ice —perhaps not much more than the ice-fringes of the present day. Many portions of the southern highlands do not rise to any such altitude to be easily barricaded with the small amount of floating ice indicated by the transported material.

There seems a difficulty in explaining the absence of marine life in this area when it is found in the bed of the St. Lawrence valley, unless the whole period was one of comparatively short duration, and marine life did not get farther westward than the present outlet of Lake Ontario.

The Drainage of the Inland Sea.—This inland body of water, as the continent was gradually rising from beneath the sea level,

evidently had a large number of outlets at different times by which it connected with the outside ocean. These old outlets are indicated by a number of river-like valleys crossing the highlands of Ohio and New York (not to refer to those extending from the valley of Lake Michigan and the present St. Lawrence valley). The following are the most conspicuous ancient waterways: Through the highlands of New York; 1, by the Mohawk river, at 434 feet above tide; 2, then by the valley of Tully lakes, at about 1200 feet; 3, by the valley of Skaneateles lake, at about 1200 feet; 4, by the valley of Owasco lake, at 1232 feet; 5, by the extension of the valley of Cayuga lake, at 1015 feet; 6, by the valley of the extension of Seneca lake, at 865 feet above mean tide; and several others at greater elevations. All these valleys are from 100 to 300 feet or more beneath the adjacent highlands. In Ohio, Dr. Newberry enumerates the following ancient channels:—1, by the valleys of the Grand and Mahoning rivers, at 936 feet above tide; 2, by the valleys of the Cuyahoga and Tuscarawas rivers, at 968 feet; 3, by the valleys of Black and Styx (a tributary of the Tuscarawas) rivers, at 909 feet; 4, by the valleys of Sandusky and Scioto rivers, at 910 feet; and 5, by the valleys of the Maumee and and Miami rivers, at 940 feet. The summits of all these valleys are more or less filled with stratified drift, and in some cases, as that of Seneca valley, the summit forms a long, nearly flat alluvial plane, free from boulders. All these valleys of New York, on the northward side of the divide are deeply underlaid by sediments, whilst to the southward, exposures of rocks along their beds are much more common. The remarkable connection between these old outlets and the beaches is very striking. Thus, there are at about the level of the lowest of these outlets, 434 feet, beaches on both the southern, western and northern boundaries of Lake Ontario at corresponding heights. Also, at the level of the next lowest enumerated outlet (by Seneca valley) at 865 feet, beaches were produced (only a few feet higher corresponding to the outlet through which water a few feet deep was passing), in New York (north end of Skeneatles lake), in Ontario (north of Toronto), and even in the region of Lake Superior.

Erratics and Origin of the Gravel of the Beaches.—Almost everywhere in the "region about the western end of Lake Ontario," well water-worn boulders of Laurentian and Huronian rocks are occasionally to be met with, and in some places they

are abundant. They are abundant in such remnants of the boulder clay as exist, and in portions of the lower beds of stratified clay. At the western end of Lake Ontario they are not found in the Saugeen clay. However, in the later terraces they are found, though usually of small size. On the surface of the country above the Niagara escarpment they are met with much more frequently than below the escarpment (where they are very rare unless derived from one of the beaches). On the upper levels of the Dundas valley none are to be seen. The "Artemesia gravel" contains many. It also in places contains large quantities of the water-worn remains of Hudson river rocks, all derived from lower levels. Along Rosseau creek, in Barton township, there is a group of semi-rounded boulders two feet long, composed of Medina sandstones, whose outcrop is only two miles away, but at an elevation of two hundred feet lower, beneath the Niagara escarpment. The northern erratics are much more abundant and larger on the highlands of New York and Pennsylvania than at lower levels at the western end of Lake Ontario, and occur on top of the terrace deposits. Besides these deposits and the Devonian pebbles of New York, carried to higher levels, the materials of the beaches are derived more or less from the adjacent rocks. There seems, as far as Ontario is concerned, but one explanation for the lifting of these water-worn pebbles and boulders to higher levels, and that is their transportation and elevation by the slow agency of coast ice forming in many succeeding years during the time of continental subsidence, as we see to-day the large boulders in many of the north-western shallow lakes lifted from their beds, by the action of the thick winter ice, and drifted on some portion of the shore by the prevailing winds, there to be left on the dissolution of the ice, as reef several feet higher than the lake surfaces. Again, as the waters were receding many of the boulders along the coast would again be picked up by the annual ice, and transported to hills, and growing beaches which are now the highlands to the south, while the intermediate deeper beds received but few, rarely dropped by the passing ice. In regions less exposed to currents and shore deposits but little stony material was deposited, as is demonstrated in the upper portion of the Dundas valley and elsewhere. There does not appear to have been a large amount of floating ice, as indicated by the fine material over the beds of some of the old outlets noticed already.

The beaches at the higher levels are composed of much more local *débris* than those at 116 feet and at the present water level, about the western end of Lake Ontario now to be described.

Burlington Heights and Burlington Beach.—The lower part of the Dundas valley and the site of Burlington bay were excavated out of the Erie clay during the period of elevation of land that followed that epoch, and the interglacial Grand river flowed down this valley in the same way that the Niagara river flowed down the St. David's valley. These valleys became closed, however, during the deposits of the Saugeen clay and the terraces (the visible surface for a depth of 200 feet in the St. David's valley shows only stratified sand, and was not closed up by glacial action as has been suggested). Therefore the deposits of Burlington heights (and the 116 feet terrace) were not brought down the Dundas valley. Moreover, I have never seen a solitary Niagara pebble in this terrace, though sought for. Again, the Hudson river pebbles in the Dundas beaches at higher levels are all very small, whilst both the 116 feet terrace and the present lake beach contain some strata of cobble stones from four to six inches in diameter, with oval (water-worn) slabs from one to two feet long. The materials of these beaches have all been derived from the *débris* of Hudson river rocks and contain a small quantity of crystalline pebbles of moderately small size. The nearest exposures of Hudson river rocks is at Oakville (20 miles distant), but at a lower level. However, at Weston (30 miles distant) west of Toronto, the same rocks occur at 179 feet (and lower) above Lake Ontario. The shape of the pebbles is flattened oval, they were evidently derived from these northern exposures and transported around the whole western end of the lake to form the conspicuous terrace of 116 feet and the present beach. This transportation has been effected by the action of the waves and floating coast ice when the water was at the respective levels. The present beach may have been in part derived from the denudation of that 116 feet.

Burlington Heights forms the extreme western end of the bay of the same name and the Burlington beach, the end of Lake, Ontario. The Heights, varying from less than a quarter of a mile to a few hundred yards in width, separates the Dundas marsh (at the same level) from Burlington bay. The width of the marsh here is about half a mile. At the northern end, it was formerly connected with the bay by a ravine partly filled by

a railway embankment after the heights were cut through for Desjardins canal. The elevation of the Heights is 108 feet above the lake, and is the connecting link between the terraces on both sides of the Dundas marsh, whose valley was excavated before their deposit. Burlington beach, from 300 to 500 yards wide, is about five miles long, and separates the bay from the lake in the same way as the Heights separate the bay from the marsh, the one being the counterpart of the other, when the lake stood at different levels. The bay inside of the beach is 78 feet deep. Neither of these beaches has been produced by sediments brought down by streams and thrown up in the form of sand bars, as in many modern harbors, because no important streams have flowed down the Dundas valley (since the epoch of high elevations at the close of the formation of the Erie clay) or do now flow. More particularly is this statement proven by the absence of all material belonging to the Dundas valley or region drained by its streams. In the Burlington Heights there is often flow and plunge bedding and slightly oblique stratification seen, which dip towards the lake. Lake Ontario never freezes more than a few miles from its margin, and even more than shore ice is uncommon. Winter storms often pile the ice and contained stones very high on the shores. Burlington bay always freezes over. It becomes apparent that both of these ridges (the latter rising only eight feet above the lake) were produced by the lake action from Hudson river pebbles and sand, transported by coast-ice and waves. Any *débris* of Hudson rocks found in the Dundas valley below 115 feet level is very small. The Laurentian pebbles are no more than the few deposited from the floating ice of the higher terrace epoch upon the region from which the detritus came.

The cause which determined the position of these ridges is easily explained. The extension of the lake into these narrow arms was frozen over during winter, not necessarily any colder than that of the present time. As the north-eastern winds were driving the coast-ice against the frozen barrier, it became broken up and deposited its burden of stones and sand in the same way that the present coast-ice with its contained stones continues to increase (though very slowly) the breadth of Burlington beach, aided with the action of the waves.

Hudson River Fossils in the last two Beaches.—Abundance of fossils occur in the pebbles of these beaches, at 116 feet above

the lake and at the lake level. They are seldom found in the arenaceous pebbles, but most abundantly in the more flattened calcareous stone. I have obtained the following fossils:—*Stenopora fibrosa*, *Columnaria alveolata*, *Athyris headii*, *Strophomena alternata*, *S. deltoidea*, *Leptœna sericea*, *Orthis testudinaria*, *O. occidentalis*, *O. lynx*, *Obolella crassa*, *Modiolopsis modiolaris*, *Modiolopsis*, (numerous undetermined species), *Cyrtodonta harrietta*, *Orthonata sp.*, *Ctendonta sp.*, *Lyrodesma poststriata*, *Ambonychia radiata*, *Avicula demissa*, *Murchisonia gracilis*, *Cyrtolites ornatus*, *Orthoceras lamellosum*, *Ormoceras crebiseptum*, *Leperditia Canadensis* and tails of *Calymene*.

Life Belonging to the Terrace Deposits.—Dr. Bell gives a list* of many places in Ontario where the stratified gravels and sands contain fresh-water shells. To his list other collectors have added localities. However, about the western end of Lake Ontario they are very rare, and I have seen only one or two localities where they are found although they occur near Niagara Falls.

The principal locality is not in the terraces, but will be described below.

However we have remains in Burlington Heights more interesting than shells. Many years ago in making the cutting through the heights of the Desjardins canal, at an elevation of 70 feet above the lake (about 38 feet below the summit), remains of the mammoth *Euelephas Jacksoni;* horns of a wappti, *Cervus Canadensis*, and the jaw of a beaver, *Castor fiber*, were found. In 1876, while making another excavation in the Heights the workmen found a tusk and one vertebra of a mammoth. At a depth of 30 or 40 feet from the top of the terrace there could have been no beach on which these animals might have wandered. Were the animals then unfortunate enough to be carried thither on the ice, were they drowned in attempting to cross from one side of the ancient valley to the other, or were their bones carried thither by the floating ice?

In several of the swamps north of Lake Erie teeth and bones of mastodons have been found, but these belong to more modern deposits.

XI.—MODERN DEPOSITS.

Most of the deposits of the present time consist of the soils carried down by the streams into the Dundas marsh and Lake Ontario.

---

* Geol. of Canada, 1863.

One deposit now completed does not belong to this class. Just west of the Catholic cemetery at Hamilton and bordering on a branch of the Dundas marsh we find a bed of shell marl. This is almost entirely made up of broken shells, and contains also the following modern species in a state of preservation:—*Patula alternata*, *Triodopsis trideatata*, *Mesodon albolabri*, *Succinea*, *obliqua*, as recognized by Mr. Whiteaves. This deposit has a thickness of about 15 feet extending to that height above the marsh.

Some interesting facts with regard to the modern deposits in our lake and the Dundas marsh have recently come to light. The area of the Dundas marsh is rather more than two miles. It is generally shallow and filled with reeds. In the eastern portion there are some deeper places where the reeds do not grow, it is being rapidly filled by the accumulations of the sediments from the streams emptying into it. The deposits are now principally made during the increased flow of water of the spring freshets. A constant source of trouble has for many years been experienced by the silting up of the Desjardin canal, which passes through the marsh. As late as 1860 or 1865 the western end of the marsh was frequented for skating purposes; the same portion is now turned into fertile meadows. For nearly a score of years the proprietors have been trying to recover the land by making dykes. One dyke after another has been encroaching on the marsh until a considerable area is now drained. In making one of these dykes a trench was sunk to a depth of several feet, and at six and one-half feet from the surface Mr. James Chegwin came on a bed of saw-dust six inches in thickness. This was in the year 1876. On making inquiry, I learned that the first saw-mill in the region began operations about the year 1811. Thus we see that from the time that the saw-dust was brought down from Mr. Green's mill, in the Lindsay creek, a deposit of mud six and one-half feet thick accumulated in a period of about sixty-five years, or that the rate of deposit is about a tenth of an inch per annum. It is probable that at the present time the accumulation is more rapid as the area of the deposit has been considerably lessened. The parts of the marsh outside and adjacent to the dykes are now entirely above water in the later portion of the summer. This setting up is continuing until the spring freshets can no longer overflow the low land, when all the sediments are carried into deeper water. Seasons of high water in

the lake, of course, favor the thickening of the soil near the surface, when perhaps the succeeding season will be accompanied by low water, with the consequent distribution of the sediments in only the deeper portions of the area.

Lake Fluctuations.—In order to ascertain what proportion of the elevation of the bottom of the swamp was due to the sediments. I succeeded in getting some of the records of the fluctuations of the lake levels. In a Smithsonian contribution Col. Whittlesea has published a more or less complete register of the fluctuatiou of Lake Ontario at the port of Oswego between the years 1815 and 1857. The earliest of these records begins in 1815 and is continued for the next twelve years, during which time the annual fluctuation was very considerable, the extremes being as much as 4.5 feet. From 1840 to 1853 the maximum difference of levels was only two feet; while that from 1859 to 1873 (obtained from other records) was 2.8 feet.

The question arose whether the lands were rising (or water sinking) or not. At Oswego the mean height of the water between 1840 and 1853 was about nine-tenths of a foot higher than between 1815 and 1827. As the records obtained from 1859 to 1873 are not from same datum I cannot compare them with previous years. But if we take the heights from 1859 to 1866 inclusive, and those from 1867 to 1873 inclusive we find that during the later period, at Oswego, the waters were about nine-tenths of a foot lower. The table of fluctuations (obtained from Captain Fairgrieve, of Hamilton) for Toronto Harbor shows that the mean height of the water between 1874 and 1865 was one foot lower than that between 1864 and 1854 inclusive. In computing these heights the records for two years in each period are incomplete, therefore they have not been included in the calculations. The following are the mean heights of the lake at Toronto above a given datum mark for the years:—

1854	1 55 feet.	1865	1.00 feet.
1855	1.30 "	1866	—
1856	1.46 "	1867	1.10 "
1857	—	1868	0.60 "
1858	2.25 "	1869	—
1859	2.33 "	1870	2.50 "
1860	1.42 "	1871	0.83 "
1861	—	1872	— 0.40 "
1862	2.17 "	1873	0.40 "
1863	1.62 "	1874	1.00 "
1864	2.70 "		

The greatest fluctuation in the 21 years was 3.1 feet, at Toronto (omitting the four years '57, '61, '66, '69). From these fluctuations of the lake it can be seen that the position of the greatest deposition in the marsh will be somewhat changed in different years, as much of it is very near the water level. During a continuance of years of low water the sediments would be carried farther by the streams and consequently the higher grounds would not receive additions.

Filling up the Western End of Burlington Bay.—Grindstone creek empties into the western end of Burlington bay, and the currents principally pass close to the eastern side of Burlington Heights. As this stream brings down a large quantity of mud and, although emptying first into a swamp of its own), a considerable amount of sediment is carried into the bay and is deposited in the quieter waters near Carrol's point, at which place there is a long bar (submerged at high water) where these currents meet the waves of the open bay. This portion of the bay is fast becoming a swamp.

XII.—LAKE MEDAD.

About two miles northward of Waterdown, there is a small pond—Lake Medad—half a mile long. In the western part of Dundas valley there is a number of small ponds amongst the hills of drift material, but these are only small expansions of the various streams at heights from 510 feet to 240 feet above the level of Lake Ontario. On one side of Lake Medad there is a rugged shore of deeply weathered dolomites, extending more than 20 feet above its waters. The shore beneath is composed of a beach of pebbles. The opposite side of the lake is shallow, and is now occupied by a marsh. This lakelet is not an expansion of any modern rivulet. A number of insignificant streams empty into it, but not one of which could possibly have excavated the present basin. This lakelet is not on the uppermost portion of the Niagara escarpment, but in a somewhat broadly rugged country. The basin of Lake Medad is evidently a filled up portion of a larger water channel that became blocked by drift material, which it has been unable to clean out for itself in modern times. The whole lake could be drained by cutting through the drift deposits which occupy one of its extremities. I was informed by one of the inhabitants that he had discovered an underground outlet, so that a portion of the waters discharge by a stream directly into Lake

Ontario, while at present, the small visible outlet is by Grindstone creek, through Waterdown.

Comparing it with Lake Ontario, it has its Niagara escarpment on one side and on the other a gradually shallowing shore towards an area evidently filled to some depth with drift material analogous to the soft Cambro-Silurian rocks north of Ontario, whilst its outlet is blocked up, as the the greater lake is, in its south-eastern extremity.

Thus I will close a fragmentary work, which will, I hope, assist in the study of the surface geology of Ontario, and also give more prominence to the almost undeveloped subject of Fluviatile Geology.

(Having learned the value of accurate elevations, I have collected the levels of most of the railways in Ontario and some other lists of elevations which will follow the present paper.)

PLAN OF FOREST PLANTING FOR THE GREAT PLAINS OF NORTH AMERICA.

By H. M. Thompson, Lake Preston, Dakota, U.S.A.

Read before the American Forestry Congress, Montreal, August. 1882.

In devising or advocating plans for forest planting, on the Great Plains which will prove to be generally beneficial in ameliorating climate, due consideration must be given to the physical features and to the meteorological conditions. These features and conditions may be briefly stated to be as follows:—

The Great Plains extend from the southern limit of the Staked Plains in Texas northwardly about 20 degrees of lattitude to the Saskatchewan river and Hudson's Bay, and from an irregular east line, commencing in Texas, running through the eastern part of the Indian Territory, Eastern Kansas and Nebraska, Western Iowa, the Bigwoods of Minnesota, and the Red river of the North; westwardly of this irregular eastern limit an average distance of about 10 degrees of longitude to the foot-hills of the Rocky Mountains, and containing an area of about 950,000 square miles. If all this region possessed a propitious climate, and all the soil were susceptible of culivation the area is sufficient to make 3,800,000 farms of 160 acres each, and which, by the aid of a proper forest economy, may be made capable of supporting an agricultural and pastoral population of fifty millions. This vast region, with the exception of the Black Hills, the Des Coteaux, and a few isolated mountains, may be said to be a level, or slightly undulating plateau, having an altitude of a few hundred feet in the eastern part, to several thousand in the western portion above tide water. The plateau is intersected by the Red river of the North flowing northwardly, and bisected by the Missouri, the Arkansas, the Red river of the South and their affluents, which with few exceptions, are of minor size "being raging torrents to-day and dry water courses to-morrow." The entire plateau is treeless, with the exception of narrow fringes of forests skirting the margin of the streams, the Des Coteaux, the Black Hills, the lakes and the few isolated mountains dotting the plains.

The soil of the eastern, and a portion of the southern district seems to contain most, if not all the mineral constituents needed for the successful growth of agricultural products, and for the native grasses and thus to possess an unlimited capacity

for grazing flocks and herds. The soil of the central, the western and southwestern districts is more varied in its general characteristics, there being considerable areas of arable land capable of sustaining a vigorous vegetation, alternating with the sage brush plains.

The winter climate of the eastern part of the Great Plains is subject to sudden changes of heat and cold, with a dry atmosphere in the north more or less humid in the south. The snow drifts over an area hundreds of miles in extent. By such constant motion and atrition the flakes of snow become comminuted into minute particles. When in this condition accompanied by a low temperature and violent winds it fills the atmosphere so completely as to obstruct the vision. These terrific drifting snows are denominated blizzards, and often prove destructive to man and beast. The meteorological conditions prevailing in the summer are high temperature during the day, low temperature and heavy dews at night, constant winds varying from the moderate velocity of zephyr breezes to tornadoes and cyclones, slight rain falls or torrential floods and occasionally hailstorms, nearly all of the summer storms being accompanied with electrical disturbances unusual in forest regions. On the western portions of the Great Plains the aridity is so great that no certain reliance can be placed upon the productions of cereals and vegetables without irrigation. The constant winds of the Great Plains moving over the thousands of miles of space with no great chains of mountains or forests to impede their progress, and with nothing but the diminutive native weeds and grasses, to shield the earth's surface from the intense heat of the sun's rays, penetrating through an arid atmosphere, cause rapid evaporation of moisture from the soil. This moisture is wafted by the winds to where Nature's forest garb, by means of its cooling atmospheric influence lowers the temperature and enables Mother Earth to appropriate from the clouds formed in unforested climes, the moisture required for the sustenance of the vegetation clinging to her bosom for support.

The soil of the Great Plains containing all the constituents requisite for a varied vegetation, is capable of supporting an immense agricultural and pastoral population, to grow surplus products to meet the requirements of the commercial, mining and manufacturing population of other portions of the continent. In order to accomplish this, climatic conditions must be modified.

This result can be accomplished only by means of cultivated forests. The extent of the forests to be effective, must be commensurate with the vast area. The forests must be planted in such form as will generally shield the earth's surface from the sun's rays, and afford the greatest possible general resistance to surface winds, and harbor insectivorous birds; provide for the constant and equal distribution of electrical currents; provide for equalizing temperature and moisture; prevent the rapid flow of surface water; make provision for the retention of snow, and the prevention of the drifting of the soil of cultivated areas.

As yet no general system of planting has been put in operation to meet these requirements. In the group form of planting generally in vogue, for the purpose of growing timber for economic use, there may be a manifestation of some beneficial climatic results. It is apprehended, however, that such form of planting can but otherwise result in sudden changes in temperature, and in such disturbance of electrical and atmospherical currents as tend to increased occurrences of tornadoes and cyclones, as instanced in the destructive effects of storms in Kansas, Nebraska and Iowa, where they seem to increase in frequency and in desstructive power in a ratio corresponding with the increase of the erection of habitations and other surface improvements and the increased area and growth of the cultivated forests planted in the group form.

It must be concluded, therefore, that the shelter-belt system is the best form of forest-planting for extensive plains. This form of planting has been advocated for many years in America. The principal, if not all the experiments in this direction, have been made by individual effort in isolated areas, and on a small scale, having usually been made to the extent of a few rows of trees around buildings, stock yards, gardens, and in some instances, around farms of considerable extent. These plantings have generally been made with the object of obtaining shelter only.

This system of planting on a more extensive scale, hovever, in which the shelter-belts are to be planted with all the trees needed for economic use, as well as for the purpose of shelter is, if we except the Des Coteaux, the Black Hills, and isolated mountains. applicable to the general topographical features and climatic requirements of the Great Plains.

These forest belts may be planted seven to ten rods wide around all sides of each 160 acre tract of land, or the shelter-belts

may be of less width, and the 160 acre tract subdivided by substituting inside belts of such width that the land planted may equal $\frac{1}{4}$ or $\frac{1}{5}$ of the whole area; or the plantings may be commenced two or three rods wide upon the north and west sides of the land, and further extended year by year as the means of the planter will permit until the maximum area is completed.

The first planting of trees may be profitably composed of such species as are indgenous to the locality, such as box, elder, cottonwood, soft maple, ashes, white and golden willow, European alder, catalpa, locust, butternut, black walnut, hickory, birches, larch, hardy evergreens and other species of trees as may be adapted to the soil and locality.

In after years, when the first planted trees become of sufficient size to afford shelter, other species considered of doubtful adaptation, or too tender to endure the climate without protection, may be planted inside of the shelter belts already established, and perhaps prove useful and remunerative to the planter.

If it be conceded that all things considered, the shelter-belt form will promote the increase of insectivorous birds; modify electrical conditions; lessen the evaporation of moisture from the soil; retard the velocity of surface winds; cool the earth and atmosphere in the summer; raise the winter temperature; increase the volume of atmospheric moisture; lessen blizzards in the north; lessen the liability to drifting soil and snow and mitigate the destructive effects of tornadoes and cyclones; make the soil more uniformly productive, and thus make the great plains the grazing ground of countless flocks and herds, and become the granary of the continent; our obligations to ourselves, to our country and to untold millions of the human race yet unknown, will be fulfilled only where large belts of forests are on these Plains.

The establishment of a general shelter-belt system of forest planting for the great plans cannot be inaugurated too soon.

Individual effort in this direction, without the encouragement of wise legislation on the part of the respective Governments, will be isolated and the results too limited and too remote to be appreciably beneficial, hence the necessity of legislative action.

If history's teachings are true criteria, the wealth, power and prosperity of nations largely depend upon a successful agriculture; but a permanently successful agriculture cannot exist without the aid of a wise system of forest economy. A large part

of the great plains is as yet public domain, and the respective Governments can by enactment embody a system of forest planting as a condition of grant or sale, and if need be, for the public good, may extend its requirements to lands owned by individuals and corporations. It then seems to be the part of wisdom for the respective Governments to inaugurate, at an early day, legislation providing for a general system of shelter-belt forest planting, applicable to the Great Plains, with discretionary powers vested in a special bureau of forest commissioners to make such modifications as might be required for the planting, on the margins of lakes, streams, hill-sides and mountain slopes. And in furtherance of this plan it would undoubtedly be wise to make suitable provision, in grants of land, to the territories when admitted as States by the Congress of the United States, and to the Provinces by the Dominion of Canada, for the purpose of establishing one or more experimental forest stations in each State and Province, under proper restrictions and conditions, with provisions requiring annual reports of experiments and observations to be made to the respective States and Provinces and to their respective general governments, which should also be distributed to other nations and all scientific associations of a national character, as an exchange for reports bearing on similar topics.

THE DENUDATION OF OUR FORESTS.

By G. L. Marler.

Read before the American Forestry Congress at Montreal, Aug. 22nd, 1882.

Having had twenty years' experience as a forest ranger on the south shore of the St. Lawrence I can speak on this subject from personal knowledge. The Province of Quebec is one of the principal territories from which mercantile lumber is drawn. When I speak of mercantile lumber I refer to that which is obtained from the following trees:—

Deciduous—Oak, elm, ash, birch, walnut, butternut, hickory, ironwood, maple, basswood, white birch, beech, poplar, cherry, balm of Gilead, plain tree, willow.

Evergreens—Pine, spruce, larch, cedar, balsam, hemlock.

There are two large belts of timber land in the Province of Quebec, one on the south side and the other and greater on the north of the St. Lawrence. The first extends from Gaspé to the head waters of the Connecticut river and from the banks of the St. Lawrence to the line separating the Province from New Brunswick and the United States. This belt contains about 30,000 square miles. The other extends from below the Saguenay to the Ottawa, and from the St. Lawrence northward 200 miles. It contains about 120,000 square miles.

Until a few years ago these great belts of timber land were reached only by the streams running through them, and could only be devastated by the lumbermen a few miles each side of these rivers, leaving large spaces untouched by the woodman's axe. But during the last twenty years this great belt has become the field of some dozen railroads, which have cut up the land like a checker board, and we must expect that in another ten years this belt will be entirely denuded of all merchantable timber.

The northern belt is now passing into the same phase as the southern. The rivers on the north shore are not so numerous as on the south side of the St. Lawrence, but they are of greater magnitude and extend further into the interior. Like the other belt, it is now being cut up by railways. If we open the Government statistics book we find that the gross returns of the forests for the year 1881 amount to the neat little sum of $24,-802,064, and as compared with the total exports of the Dominion of Canada, are equal to ¼ of the total amount, $92,000,826.

According to Government returns for 1871, the value of timber exported was $22,872,591.

Comparing the year 1881 with the year 1871 there is an increas of $2,000,000.

I have found that in 1871 the cut of timber as reported to Government was:—

White Pine	24,236,821	feet.
Red Pine	1,954,371	"
Oak. r.	3,302,043	"
Tamarac	5,695'963	"
Birch	1,939,357	"
Elm	1,832,624	"
Walnut	117,589	"
Butternut	102,981	"
Hickory	197,827	"
Other kinds	26,290,264	"
Pine logs	12,416,408	"
Other logs	9,314,557	"
Masts	121,685	"
Staves	34,706	M.
Lath wood	25,706	Cords.
Tan bark	162,521	"
Firewood	8,713,083	"

Now reducing these several quantities to trees, we have an aggregate of 22,271,384 trees. If you say 50 trees to the acre, we have denuded in one year 545,428 acres, equal to three townships. There have expired since this return was made 10 years, which gives no less than 30 townships, equal to 3,240 square miles, or three whole counties, supposing each county to consist of ten townships. Having ascertained the total amount of exported timber, we must not forget the home consumption, which exceeds that exported.

Now what have we done in the way of preservation? Very little indeed.

The Quebec Legislature by an Act of 1882, chap. XIII., offers a bonus of $12 per acre to any one who will plant an acre of ground with trees, and keep it well preserved. It has passed an Act, 1882, chap. XI., to the effect that no person shall burn or set fire to any timber for the purpose of clearing land, from 1st July to 1st September.

The Government, in making their yearly estimates, generally amongst the items of revenue, state that they will get so much from forests. Now, when they make or prepare their estimates, they should carefully ponder on this item. It is not an annual revenue, it is absolutely taken from capital, which capital is being so rapidly reduced that ere many years the balance must be considered as *nil;* thay are killing the goose that is laying the golden egg, in fact they have nearly reached the backbone. I have now

to stop and consider our present position, and ask what must be done for the salvation of our trees—is there any means to replace the millions of tree that are cut down annually? I reply in the affirmative; every one has the power and capacity to aid in this great work. Does not every tree bear it own seed? And sowing or planting trees is no harder than sowing grain.

I have made a calculation that 200 acres (lots such as the present divisions of our townships) planted with a double row of trees, say maple, will give a belt of trees nearly three miles long and a plantation of sugar or other trees. Experience has shown that from 100 feet square of well prepared land sown with ash there can be transplanted enough to cover 100 acres. A return can be obtained after three years, as the smaller trees removed in thinning can be utilized for hop poles, etc. If the soil is well prepared a farm planted with trees will begin to give a return after three years at the rate of $10 per acre, increasing year by year to $40.

MISCELLANEOUS.

Worms and Crustacea* is the title of Vol. vii. of the "Guides for Science Teaching," issued by the Boston Society of Natural History. This excellent little work of 68 pages is specially intended for the use of teachers, but will also be found of great service to those who desire in private to obtain a general knowledge of the structure of the groups of animals of which it treats. The first sixteen pages are devoted to a description of the common earth-worm, and the Nereis or sea-centipede, which are taken as types of the classes to which they belong. The remaining portion of the book contains a very accurate description of the lobster, a crustacean easily obtained for study, and notes points in which other groups of crustaceans differ from that taken as the type. The book contains a large number of very good drawings, greatly enhancing its value. We can scarcely see how the publishers can give so much for so small a sum, the price of the book being only thirty cents.

---

* "Worms and Crustacea," by Alpheus Hyatt, Boston Society of Natural History. (Ginn, Heath & Co., Boston).

Published, 22nd Sept., 1882.

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

THE PROGRESS OF AMERICAN MINERALOGY.

By G. J. Brush,

(Address of retiring President before American Association for the Advancement of Science. Montreal, August 25th, 1882).

The change in the constitution effected at our last meeting, extending the scope of the Association and dividing it into nine sections, each with a Vice-President, whose duty it is to deliver an an address to the section over which he presides, has relieved the retiring President from attempting a general review of the progress of science during the past year. I turn, therefore, to a more special subject, and invite your attention this evening to a sketch of the progress of American Mineralogy since the commencement of this century, with particular reference to the labors of some of the early workers in the science on this continent. During the last quarter of the eighteenth century, while great activity existed and rapid advance was made in the study of chemistry and mineralogy in Europe, almost nothing was accomplished in this new country. It is true that students in other departments of science, especially members of the medical profession in the cities of Philadelphia, New York and Boston, attempted to arouse an interest in mineralogy, believing that the diffusion of a knowledge of this science would be of the utmost importance in the material development of the country. There were, however, no text-books to aid the inquirer. There were no collections of minerals to stimulate the student. In the absence of these it was almost impossible that an interest in this science should be fostered, or that a spirit of investigation should be awakened. As the first distinct beginning of the science, I

may mention an association formed in 1798 in the city of New York, which assumed, as they expressed it, "the name and style of the American Mineralogical Society." It announced as its object "the investigation of the mineral and fossil bodies which compose the fabric of the globe, and more especially for the natural and chemical history of the minerals and fossils of the United States." The distinguished Dr. Samuel Latham Mitchill, who seems to have been a man of universal genius, was at once its first President, its librarian and its cabinet-keeper. The committee of the society issued a circular in which, while expressing themselves, "desirous of obtaining and diffusing by every means in their power a correct and extensive knowledge of the mineral treasures of their country, they earnestly solicited their fellow-citizens to communicate to them on all mineralogical subjects, but especially on the following, viz.:—

"Concerning the stones suitable to be manufactured into gun-flints: where are they found? and in what quantity? 2. Concerning native brimstone or sulphur or the waters or minerals whence it may be extracted? 3. Concerning saltpetre: where (if at all) found native? or the soils which produce it in the United States? 4. Concerning mines and ores of lead: in what places? the situation? how wide the vein? in what kind of rock it is bedded."

This warlike demand seems to call more for the discovery of the materials for national defence than for the advancement of science, and besides being a commentary on the spirit of the times, gives a rather humorous impression of their strangely inadequate conception of the science of mineralogy, and its possible bearings on practical life, but in justice to them I should add that it is further announced that "specimens of ores, metals, coals, spars, gypsums, crystals, petrifications, stones, earths, slates, clays, chalks, limestones, marbles and every fossil substances that may be discovered or fall in the way of a traveller, which can throw light on the mineralogical history of America, will be examined and analyzed without cost, sufficient pieces, with the owner's leave, being reserved for placing in the Society's collection." I have quoted the circular almost verbatim to give you some idea of the genuine though crude longings for knowledge felt by our early mineralogists, and also of the generous spirit in which they worked. A still more forcible picture of the ignorance of the time is given by the elder Professor Silliman in 1818, "Notwithstanding the

laudable efforts of a few gentlemen," he says, "to excite some taste for mineralogy, so little had been effected in forming collections, in kindling curiosity and diffusing information, that only fifteen years since (1803), it was a matter of extreme difficulty to obtain among ourselves even the names of the most common stones and minerals; and one might inquire earnestly and long before he could find any one to identify even quartz, feldspar or hornblende among the simple minerals, or granite, porphyry or trap among the rocks. We speak from experience, and well remember with what impatient, but almost despairing curiosity we eyed the bleak, naked ridges which impended over the valleys and plains that were the scenes of our youthful excursions. In vain did we doubt that the glittering spangles of mica, and the still more alluring brilliancy of pyrites, gave assurance of the existence of the precious metals in those substances, or that the cutting of glass by the garnet and by quartz proved that these minerals were the diamond; but if they were not precious metals, and if they were not diamonds, we in vain inquired of our companions, and even of our teachers, what they were." Such, then, was the state of knowledge in mineralogy here at the commencement of the century. A few American minerals, collected by travellers from time to time, had before this been taken to Europe for identification, but among these were discovered only two minerals new to science. The Moravian missionaries found at St. Paul, in Labrador, the beautiful species of feldspar called by Werner *Labradorstein*, which in more modern times we know under the name of *Labradorite*. Klaporth, the most eminent analytical chemist of his time, discovered that the so-called fibrous barytes from Pennsylvania was the sulphate of the then newly discovered earth strontia. He thus, for the first time, identified the mineral species *celestite* which was subsequently found in various localities in Europe. Although little had been accomplished in America previous to 1800, the first quarter of the new century was destined to show great development here in the study of mineralogy. During the early years of this quarter several collections of European minerals were brought to this country by American gentlemen, who had availed themselves during a residence in Europe of the best opportunities for acquiring a knowledge of the science from the great masters of the subject in Germany and France. About this time also several colleges in the country had instituted chairs of chemistry and mineralogy, and a commence-

ment was thus made in teaching these sciences in the higher schools. As the result of these influences the number of persons interested in mineralogy was largely increased, and an active search for minerals was initiated throughout all of the older United States and to a considerable extent also in Canada. So energetically were these explorations followed up that in 1825 a Catalogue of American minerals was published by Dr. Samuel Robinson, with their localities arranged geographically, and giving only such as were known to exist in the United States and the British Provinces. It formed an octavo volume of over three hundred pages. That much credit was due to many workers during this period, both in the field and in the laboratory, there can be no question, but among them all I find four men standing forth so prominently as leaders that I have thought that it would be well for us to recall briefly something of the character of these men and their labors for the advancement of mineralogy in this country. First among these I will mention Dr. Archibald Bruce. He was the son of Dr. William Bruce, a surgeon in the British army, and was born in New York in 1777. He was graduated at Columbia College, subsequently studied medicine, and in 1798 went to Edinburgh, where, in 1800, he obtained his doctor's degree from that University. He was early interested in natural science, and while still in college found, his biographer says, "the collection and examination of minerals—a pursuit not then at all attended to in this country—was his particular relief from other studies; for even during his recreation he was ever on the lookout for something new or instructing in mineralogy."

When he went to Europe he took with him a large number of American minerals, and through exchanges with institutions and prominent mineralogists abroad, he established friendly relations with those most interested in his favorite science. After the completion of his medical studies, he travelled for two years on the continent of Europe, making the acquaintance of the Abbé Haüy, and other eminent mineralogists, and collecting an extensive cabinet of valuable minerals, which on his return to this country in 1803, he brought with him to New York. This collection, with another brought to New York about the same time by Mr. B. D. Perkins—both being made fully accessible to all interested in seeing them—contributed, it was said, more than any agencies had ever done before, to excite in the public an active

interest in the science of mineralogy. Besides this Dr. Bruce entered into extensive correspondence with others interested in the subject, was active in visiting and discovering new mineral localities, and in advising, encouraging and inspiring young mineralogists. Finally, after well considering the matter, he established the first purely scientific periodical ever published in America. This was called the *American Mineralogical Journal*, and the first number of it was published in 1810. It contained original contributions, chiefly on mineralogy, from a number of investigators. "It was received," says the elder Silliman, "in this country and in Europe in a flattering manner; it excited at home great zeal and effort in support of the sciences which it fostered, and abroad it was hailed as the harbinger of our future exertions." But alas! it was in advance of the age, and after struggling for several years was given up on the publication of the fourth number. Possibly it would have continued longer had it not been for the failing health of its founder. This journal contained several important papers by Dr. Bruce, among them the investigation and description of two new mineral species, the native magnesia of Hoboken and the red zinc oxide of Sussex Co., New Jersey. These are the first American specimens described by an American mineralogist. So thoroughly was the work done by Bruce, that three species remain to-day essentially as he described them, and his papers may well be studied by mineralogists now as models of accuracy and clearness of statement. Dr. Bruce did much also for the elevation of the medical profession, was one of the founders of the New York Medical Society, and was largely influential in obtaining the charter of the College of Physicans and Surgeons, in which he was subsequently the Professor of Materia Medica and Mineralogy. He is described as a successful teacher, a man of wide acquirements and of great integrity, which qualities with abounding generosity and hospitality, commanded the respect and regard of all who knew him. It was a great loss to science and to his country that so able an investigator should have been cut off at the early age of 42. He died in New York, Feb. 24, 1818.

I have mentioned that the importation and exhibition of collections of minerals from Europe had contributed much to excite an interest in the study of mineralogy. It was necessary to have known minerals for study and comparison in order properly to determine those obtained by exploration here. In 1805, Colonel

George Gibbs, of Rhode Island, for many years a resident of Europe, returned from his travels with a collection of minerals, the most extensive and valuable ever brought to America. Colonel Gibbs was a zealous cultivator of mineralogy, and, fortunately for science, a young man of wealth. He used his money freely for the purchase of whole cabinets, as well as in personal explorations in search for minerals. The larger part of his collection was made by the purchase of two famous European cabinets, one from the heirs of Gigot d'Orcy, a noted French collector, and said to be the result of forty years' labor, the other from Count Gregoire de Razamowsky, a Russian nobleman, long resident in Switzerland. D'Orcy's cabinet numbered over 4,000 specimens, chiefly from France, Germany, Italy, and Great Britain; Razamowsky's contained about 6,000 specimens from the Russian empire and the remainder principally from Germany and Switzerland; in all, with the other collections made by Colonel Gibbs, it is said that more than 20,000 specimens were brought by him to this country. In 1807, a portion of the collection was opened in Newport, and many interested in mineralogy made pilgrimages there, to view the treasures it contained. Among others was Professor Silliman, who states in his diary that he spent many weeks in studying the minerals with Colonel Gibbs, finding in the latter "a scientific friend and a professional instructor and guide." That Colonel Gibbs reciprocated Professor Silliman's feelings of friendship there can be no doubt, for after various offers to deposit his collection for exhibition in Boston, New York and elsewhere, to the great surprise of Professor Silliman he proposed to open the cabinet at Yale College, provided rooms should be fitted up for its reception. The proposition was promptly responded to by the authorities of the college, and in 1810, 1811 and 1812, under the personal supervision of Colonel Gibbs, it was opened and arranged, and generously placed at the disposition of the institution and the public. The opening of this collection in New Haven formed an important epoch in the history of the college, and gave a powerful impetus to science throughout the country. It was not only studied by the pupils of the college, but it was visited by travellers from all parts of the United States. In 1825, the collection had for fifteen years been exhibited without any advantage to the owner, other than the satisfaction of observing the great amount of good which was effected by the knowledge it disseminated, and the enthusiasm

with which it inspired students. Colonel Gibbs then offered the whole for sale, giving the college the preference as purchaser. Fortunately and mainly through the influence of Professor Silliman, the institution succeeded in raising the funds ($20,000) necessary for its purchase, and the ownership of this collection has exercised a most important influence in the development of natural science at New Haven. Colonel Gibbs, however, did not confine himself to the collection of minerals in Europe. On his return to this country he made extensive journeys and opened up new mineral localities, giving his time and specimens freely to aid others who were interested in this special study. At Yale, as an incentive to students, he for many years offered prizes for superiority of attainments in mineralogical knowledge and for services rendered to the science by useful discoveries and observations. He published valuable papers both in the *American Mineralogical Journal* and the *American Journal of Science*, and did much by his counsel and co-operation to support these publications. Indeed, it was from Colonel Gibbs that Professor Silliman first received the suggestion that he should institute a new journal of science, in order that the advantages already gained by the short-lived mineralogical journal might be secured and further progress for science might be made. In every way Colonel Gibbs proved himself a liberal patron of science, and it was most fortunate for the promotion of mineralogy in this country that he should so unselfishly have devoted his wealth and his personal influence to its advancement. He died August 5th, 1833, aged 57.

Much as had been accomplished by the free exhibition of cabinets and the explorations and investigations of enthusiastic workers in mineralogy during the years from 1805 to 1815, a great drawback was now felt to the progress of the science from the want of text-books. Most of the literature of the subject was in German and French, but the works of the German and French authors had not then been translated and consequently were accessible only to the few who were acquainted with these languages. In English there were not many treatises on the subject. That by Richard Kirwan, the eminent Irish mineralogist of the last century, was a renowned work in its day, but, as the last edition of it had been published in 1794, it was already too old to be of much service to the student. Jameson's treatise was more recent (1804), but its great fullness and exclusive devotion to the Wernerian system made it an undesirable book for

beginners, aside from the fact that its price was such that few students in those days could afford to buy it. So much progress had been made at home and abroad, that a work was needed here which should include the modern discoveries, and one also which should gather up the scattered facts already published in regard to American minerals. Fortunately for the further progress of science in this country this was done by Professor Parker Cleaveland. His work was published in 1816, and was entitled "An Elementary Treatise on Mineralogy and Geology." Professor Cleaveland was professor of mathematics and natural philosophy in Bowdoin College, and like many other professors of science in the early history of American colleges was charged by the trustees to lecture also on mineralogy and chemistry. He was an enthusiatic student of mineralogy, was well acquainted with the literature of the science in various languages, had been a successful teacher of the subject for many years, and withal was both an explorer and investigator, and held intimate relations with the leading mineralogists of the day. The work was modelled on the general plan of Brongniart, combining the excellencies of both the French and German schools, and gave in detail almost everything then known in regard to American minerals. It supplied the pressing need for a thorough, systematic and American treatise on mineralogy, well suited to all classes of students, and it was written in such a masterly style that it won for its author the highest praise from the leading mineralogists of the world. "It brought," says Professor Silliman, "within the reach of the American student, the excellencies of Kirwan, Jameson, Haüy, Brochant, Brongniart and Werner, and we are not ashamed," he says, "to have this work compared with those of these celebrated authors." His biographer states that "he received letters of respect and congratulation from Sir David Brewster, Sir Humphrey Davy and Dr. McCulloch, in England; from Berzelius in Stockholm; German of Halle; from Brongniart, Baron Cuvier and the Abbé Haüy, in Paris." The work at once took rank as one of the leading authorities on the science, and was introduced as a class-book in the principal schools and colleges in America. The first edition was soon exhausted and a new and revised edition with more than a hundred pages of new matter was published in 1822. The demand was so great that this likewise was soon out of print and a third edition was called for by the public, but Professor Cleaveland had about this time become

so engrossed in the administration of the affairs of the new medical school at Brunswick that he was unable to respond to the call, having turned his thoughts and efforts in new directions. Unfortunately for the science of mineralogy, in which he had obtained such eminence as an author and teacher, he no longer contributed actively to its progress, although he continued his work as lecturer on the science so long as he lived. He died October 16th, 1859, in the 79th year of his age.

The last to be mentioned of these early leaders is Professor Benjamin Silliman. His name is so intimately associated with the progress of science on this continent during the first half of the present century, that his life-work is more or less familiar to all. But the important service he rendered in the early history of mineralogy deserves especial recognition here, not only for the work he himself did in the laboratory and the field, but because his enthusiasm and zeal were a constant inspiration to others. Commencing with the historic "candle box" of unlabelled stones which he took to Dr. Adam Seybert, of Philadelphia, to be named, he began with enthusiasm the acquisition of knowledge and the gathering of material to illustrate the mineral kingdom. During a residence in England and Scotland in 1805-6 he had opportunities to add to this information and collect many specimens, chiefly from the mines of Derbyshire and Cornwall. On his return to America he at once applied the knowledge he had acquired in making an exploration of the mineral structure of the environs of New Haven, and read a paper on this subject to the Connecticut Academy of Arts and Sciences in September, 1806. In the following year he induced the corporation of the college to purchase the mineral collection of Mr. B. D. Perkins, of New York (already referred to), for one thousand dollars, thus placing the institution in possession of means for illustrating the science of mineralogy far in advance of anything it had before enjoyed. The occurrence of the fall of the Western Meteorite in December, 1807, offered an opportunity for Professor Silliman to undertake, in connection with his colleague, Professor Kingsley, an investigation into the circumstances of the phenomena, and the character of the stones which fell at that time. The results of this investigation were presented to the American Philosophical Society and published in the *American Philosophical Transactions* in 1809. The diligence employed in obtaining all the facts possible from eye-witnesses of the occurrence,

and the care and skill shown in the chemical and mineralogical examination of the meteorite made this paper one of the most remarkable memoirs of the time, and attracted the attention of philosophers throughout the world. As already stated, it was the personal enthusiasm and magnetic influence of Professor Silliman which led Colonel Gibbs to deposit his great cabinet of minerals in New Haven, under the care of his friend. It was due to the same qualities in Professor Silliman that the college secured the permanent possession of this invaluable collection, which probably has done more to create an interest in and disseminate a knowledge of mineralogy in this country than any other single agency. The establishment of the *American Journal of Science* in 1818, now everywhere recognized as of inestimable value to all departments of science, was peculiarly helpful to mineralogy, and the early volumes are rich in articles on this subject. Professor Silliman's original contributions to science were more in chemistry and geology, but he also is the author of several important papers on mineralogy, and was the discoverer of the occurence of native tungstic acid as a mineral species. For more than fifty years he continued as a teacher in Yale college, and when he resigned his professorship, in 1853, he had the satisfaction to have as his successor in the department of mineralogy and geology Professor James D. Dana, who was already among the foremost mineralogists of the day, and whose published works, before and since his accession to this professorship, have done so much for the advancement of mineralogy. Professor Silliman retired from his active labors in his seventy-fourth year, still in full possession of his remarkable physical and mental powers, and lived honored and revered until November 24, 1864, when he passed to his rest.

It will be inferred from what has been said of these pioneers that the developments and discoveries of minerals, during the first twenty-five years of the century, were due entirely to individual enthusiasm and private enterprise. Up to this time no aid had been received from either State or National Governments, and in looking over the work accomplished during this period we are filled with wonder and admiration at the energy and rare devotion to science exhibited. The larger portion of the continent was an unbroken wilderness, and the facilities of communication even in the settled parts of the country were of the most primitive character. Yet at the present day with our means of rapid

transportation, many naturalists would hesitate to undertake the long journeys then made for purely scientific purposes. Geologists as well as mineralogists will recall how much science is indebted to such men as William Maclure, James Pierce, Thomas Nuttall (the botanist), and others who made extensive trips through the whole territory east, and in some instances, to the west of the Mississippi river. Maclure not only devoted his time and money to making and publishing a geological survey of the United States and Canada, the first report of which was made in 1809, but to him the Academy of Natural Sciences, in Philadelphia, owes its first endowment. I shall be pardoned, I trust, if I mention still another signal instance of private liberality in this connection. General Stephen Van Rensselaer, of New York, a generous patron of science, defrayed all the expenses of a geological survey of the country adjacent to the Erie canal, including the making of a geological section from Lake Erie to the eastern coast of Massachusetts. This survey was under the charge of Professor Amos Eaton, with a competent corps of assistants, and was continued for four years, from 1820 to 1824, at a cost of many thousands of dollars. Gen. Van Rensselaer was also the founder of the first school of technical science in this country—the Rensselaer Polytechnic Institute, at Troy, which was placed under the charge of Professor Eaton. It may be interesting here, in these days of Summer Schools, to recall, although parenthetically, that what was probably the first Summer School of Science in the United States was established more than fifty years ago in connection with this institution. The school consisted of a flotilla of towed canal boats, and the route was from Troy to Lake Erie. It took two months for the trip, and visited all important points on the way. Instruction by lectures and examinations was given in mineralogy, geology, botany, zoology, chemistry, experimental philosophy and practical mathematics, particularly land surveying, harbor surveying and engineering. One of the largest boats in the flotilla was fitted up as a laboratory, with cabinets in mineralogy and geology, and also scientific books for reference. Students were taught the method of procuring specimens, and were required to make collections of whatever was interesting on the route. The public mind was finally awakened to the importance of the work which these explorers and investigators had carried on single-handed. Government now came to the aid of science. In 1824 one State legislature,

that of North Carolina, authorized a geological survey to be made. This example was followed in 1830 by Massachusetts, and soon after by New York, Pennsylvania, Virginia and other States, and also by the national government, until, as is now well known, the whole territory of the United States and Canada either has been or is in the process of being surveyed. Several of the State surveys published independent volumes on the mineralogy of their respective States, and these surveys have been a powerful auxiliary in extending our knowledge of the occurrence of minerals on this continent. The opening of mines and quarries throughout the country has also furnished abundant material for study. The large number of original contributions which have been published in the volumes of State surveys, the treatises by American authors, and the still larger number of memoirs and papers communicated to our academies of science and scientific journals cannot be even enumerated in this place, neither is it my purpose to attempt to give here a list of the names of those who have been actively engaged in making researches on American minerals. Still less can I attempt to give an account of the work that has been and is being done by living mineralogists. The sketch which I have presented of the four typical workers has in a measure shown the character of our early mineralogists, the earnest spirit in which they labored, and what they accomplished in the first quarter of the century. The point to which the science has reached in the last quarter of the century cannot be unfamiliar to you all. In the time that remains I desire to call your attention to some of the developments made in the field in which our mineralogists have worked. It was thought by many scientists in the first half of this century that our rocks seemed likely to afford less variety of mineral contents than the rocks of Europe. Further study, however, and more careful and extended observations encourage us to believe that our mineral riches, even in variety of species, will compare favorably with those of other continents. Already fully one-half of the known mineral species have been found here. The present number of known minerals is variously estimated to be from seven hundred to one thousand. There have been described, as occurring here, nearly three hundred supposed new American minerals. Of these, perhaps one quarter are new to science and the remainder have either been proved to be identical with species already described, or their characters are so imperfectly given that further investi-

gation is needed to ascertain what they are. Among these new minerals are some of great interest to science. Time, however, will not allow, even if your patience would permit me, to give the facts in detail; but in justice to the describers of those announced to be new, I will print, as an appendix to this address, as complete a list as I have been able to make of the names of the proposed new American mineral species, with the names of their sponsors. The list will, I trust, be instructive both as a warning and an encouragement to investigators. The ambition to make new species is recognized as a drawback in every department of science, and mineralogy has probably not suffered in this respect more than other sciences. Nor do I believe that American mineralogists have, as a class, been less careful in describing new species than their European confrères. There have been flagrant examples of carelessness in both hemispheres, and the growing tendency during the last ten or fifteen years to call things new which have been only imperfectly investigated cannot be too strongly censured. "If two very simple rules," says a recent writer, "could be conscientiously followed by those investigating supposed new mineral species, the science of mineralogy would be vastly benefitted. These are: first, that the material analyzed, should in every case be proved by a careful microscopical and chemical examination to be homogenous; and second, that the thorough investigation which is to establish the position of a 'new species' should precede, not follow, the giving of a new name. A mineral which can be only partially described does not deserve a name." In comparing the minerals found in America with those of Europe, although interesting minor variations are observed, it can hardly be expected that very marked differences should exist. This is, of course, due to the fact, that in the inorganic kingdom, nature has everywhere to do with the same elements, under essentially like conditions. A large number of remarkable analogies between the minerals of the two continents will occur to any one familiar with the subject, as, for example, the character and the occurrence of individual minerals in the rocks of the northeastern United States and Canada as compared with those of Norway and Sweden, and numberless instances of like association of minerals in various parts of Europe find their counterparts here. A marked feature of the American minerals is the grand scale upon which crystallization has taken place, individual crystals of large size being very common. The granite veins of New

England afford striking examples of this kind. We have common mica, in sheets a yard across; feldspar has been observed where a single cleavage plane measured ten feet; gigantic hexagonal prisms of beryl, four feet long and more than two feet in diameter, and weighing over two tons, have been described; spodumene crystals six to seven feet in length and a foot or more across, and masses of rock crystal of immense size have been found. Canada and New York have given crystals of apatite, phlogopite and sphene which for these species are of marvellous grandeur in dimensions. Many other American localities might be mentioned where giant crystals occur. While it is true that these are extraordinary instances it is also true as a general fact common to a very large proportion of the minerals found in this country that the species occur in much larger crystals than those obtained from European localities. Another point worthy of note is the occurrence in comparatively large quantities, and over wide areas, of some of the rarer elements as constituents of the minerals found. In illustration of this we have, among the rare earths, *glucina* combined with silica and alumina in the mineral *beryl*, occurring in large quantity, and perhaps in a hundred or more places; *zirconia*, in the mineral *zircon*, is also very widespread in its range of occurrence as an original constituent of the older rocks, as well as a vein mineral; localities are known which have furnished this rare species by the hundredweight. The *cerium* earths are found largely in the mineral *allanite*, which occurs in so many places that it may be said to be a common mineral in the United States. These earths are also found in the rare phosphate *monazite*, a mineral that in America has a wide range of localities, and recently this species has been found in crystals of two, three, and in one instance, of eight pounds in weight. Again, three new earth metals, *mosandrum*, *phillipium* and *decipium* have been described as occurring with the cerium earths and yttria in the North Carolina *samarskite*. The rare alkali metal *lithium*, sometimes associated with the still rarer metals *rubidium* and *caesium*, is found not only of wide-spread occurence in our lithia micas, but the mineral *spodumene*, containing from five to eight per cent. of lithia, occurs by the ton in at least one locality and must be looked upon as one of the common American minerals, being found in the granite veins in Maine, New Hampshire, Massachusetts and Connecticut, and as far south as North Carolina and Georgia. Lithia is also one of the

constituents of the phosphate *triphilite*, and there are several localities known where this mineral occurs abundantly. Again we have the frequent occurrence of some of the rare metals which form metallic acids: *Columbium*, the first metal, new to science, discovered in America, associated with its twin metal *tantalum*, is found in Columbite in our granite veins from Maine to Georgia, a range of more than a thousand miles, in a score or more of places, and sometimes is obtained by the hundredweight in a single locality. The American variety of *samarskite*, another rare columbate has also been found in masses of fifty pounds or more in weight, and these acids occur in still other American species. *Molybdenum*, both as sulphide and in the oxidized form as native molybdic acid and molybdate of lead, is found in many localities, and occasionally in large quantity. Quite recently *vanadium* compounds have been discovered in several places, and *tungstates* have also been observed over a wide range of country. *Titanium* has been found in enormous quantities in extensive deposits of titanic iron as well as in the form of ratele and in shpene. The rare metal *tellurium* occurs native in Colorado and in one locality where single masses of twenty-five pounds in weight have been taken out, and several new tellurium compounds have been found in our western mines. It is, perhaps, unnecessary to enumerate more fully the many occurrences of other rare elements in American minerals. Enough has already been said to show that important developments have been made in the discovery and investigation of the minerals found in our American rocks during the past eighty years. Nevertheless it is but a commencement in the work. Only a very small portion of our territory has been explored with any thoroughness, and none of it exhaustively. The enormous production of the precious metals, and the extensive deposits of ores of the more common metals which have been opened up during the past twenty or thirty years, have placed us in tha front rank as metal producers, but we are still far behind Europe in the variety of minerals obtained from our mines. This may be due, in some instances, to the character of the veins or ore deposits, there being, as in many of our gold or silver mines, remarkably few associated minerals. In other cases, however, it is doubtless due to the fact that very few persons connected with our mines have even an elementary knowledge of the rudiments of mineralogy, while in continental Europe almost every mining officer is familiar with

all the ordinary minerals. Thanks to the traning of our schools of science, an improvement in this respect is already noticeable, as is shown in the discoveries made in the mines of our western states and territories during the past few years. While the service done for mineralogy by our geological surveys is gratefully acknowledged, we feel we have a right to demand much more from them in the future. Mineralogy has been too largely looked upon as a guide to the discovery of useful ores and minerals and not as a matter for scientific study; fortunately during the past decade the discoveries in optical mineralogy, and their importance in the determination of the constituent minerals of the crystalline rocks. have led many geologists to again recognize the desirability of a knowledge of our science. Much will be accomplished if those in charge of geological surveys will direct competent persons to make observations, not only on the main mineral constituents of rocks but also on the manner of occurrence of individual minerals. The careful inspection of quarries and mines is greatly to be desired. These are rich sources for minerals, but unless constant watchfulness is exercised valuable material for science is in danger of being buried out of sight. It is too true that many of the most interesting discoveries already recorded seem to have been due more to the result of fortunate accident than of systematic and intelligent exploration. If our trained mineralogists, instead of devoting most of their attention to the examination of specimens in cabinets collected by others would give more time to personal observation in the field in the study of the order and manner of occurrence of mineral species in place, our knowledge would doubtless be greatly promoted. Again, if our wealthy amateurs could be induced to spend their money as freely in the exploration of promising American localities as in the importation of costly European specimens, we might hope for more important discoveries, and they could have the satisfaction not only of gaining novelties for their collections, but incidentally they would do much to foster science. In order to keep pace with the progress of the science, we need many more workers who will will devote themselves especially to mineralogical research, and we need more of the spirit of the early workers. It is my belief that the number of persons at present interested in the study here, either as amateurs or investigators is relatively less than in 1825. The mineralogy of to-day is a very different subject from the mine

ralogy of the commencement of the period over which we have so hastily glanced. Then the study of minerals was confined almost exclusively to their external characters. Led by Werner, and reinforced by his most gifted pupil, Mohs, the majority of mineralogists claimed mineralogy to be a purely natural history science. They gave their attention, as has been well said, entirely to "how the mineral looked," and not at all to "what it was." On the other hand the development of analytical chemistry by the labors of Klaproth and Berzelius led many to take up mineralogy from a purely chemical stand-point. These two schools working independently brought great confusion into the science. The discoveries of Haüy in crystallography, and especially his labors in establishing a mathematical foundation for the geometrical form of crystals, and the recognition that the constancy of form depended on the constancy of the "integrant molecule," were steps which paved the way for modern mineralogy. In this a union of all the physical, geometrical, and chemical properties is required in order to determine the true character of a mineral. Further, we are called upon to investigate the history of its origin, its relation to associated species, the changes which it undergoes, and the causes and results of these changes. Here we have to do largely with both geology and chemistry. From this it becomes evident that a much broader foundation is now required for the mineralogist than in the early days of the century. The bearing of physics, geology and chemistry in the study of the mineral kingdom must be thoroughly recognized and appreciated by every investigator who desires to contribute to further progress. No mineralogist can expect to have a profound knowledge in all these directions, but he must be at least capable of intelligently applying to his subject the results obtained by experts in these sciences. Mineralogy is deeply indebted to special investigators in all these departments. Without their co-operation it would have been impossible to discover the relations of form and other physical characters with that fundamental arrangement of molecules whose nature it is now admitted controls all the properties of a substance. The study of natural crystals has afforded rich material for the physicist. In the department of optics it has given results from which many fundamental laws have been deduced; and natural crystals, too, have furnished, in many cases, the very apparatus which made investigation possible. Some chemists claim that mineralogy is

not at all a science by itself, and constitutes only a small part of inorganic chemistry. It can be unquestionably conceded that a knowledge of chemistry is fundamental, and in consequence this claim has a certain plausibility. On the other hand, we contend that it was largely the labors of the mineralogists on the physical characters of minerals, and especially their demonstration of the relation of form to chemical composition which finally awakened chemists to a more profound study of their own subject. The law of isomorphism was discovered by a chemist, whose training as an expert crystallographer in the examination of natural crystals made it possible for him to recognize the wonderful relation of form to composition. Dimorphism was first established from observations made on minerals, and it is in the study of the mineral kingdom that the laws of isomorphism and dimorphism find abundant demonstration. From the further investigation of the chemical nature of minerals we may hope for new light on the molecular constitution of substances which as yet the chemist has been unable to reproduce. We have already indicated the interdependence of geology and mineralogy. May we not claim the same interdependence of mineralogy, physics and chemistry, letting each go on in its own sphere, contributing to the general progress, sure that every new fact observed and every new law discovered will be for the common advancement of all?

INAUGURAL ADDRESS OF THE PRESIDENT OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE FOR THE YEAR 1882.

Since the days of the first meeting of the Association in York, in 1831, great changes have taken place in the means at our disposal for exchanging views, either personally or through the medium of type. The creation of the railway system has enabled congenial minds to attend frequent meetings of those special Societies which have sprung into existence since the foundation of the British Association, amongst which I need only name here the Physical, Geographical, Meteorological, Anthropological, and Linnean, cultivating abstract science, and the Institution of Mechanical Engineers, the Institution of Naval Architects, the Iron and Steel Institute, the Society of Telegraph Engineers and Electricians, the Gas Institute, the Sanitary Institute, and the Society of Chemical Industry, representing applied science. These meet at frequent intervals in London, whilst others, having similar objects in view, hold their meetings at the University towns, and at other centres of intelligence and industry throughout the country, giving evidence of great mental activity, and producing some of those very results which the founders of the British Association wished to see realised. If we consider, further, the extraordinary development of scientific journalism which has taken place, it cannot surprise us when we meet with expressions to the effect that the British Association has fulfilled its mission, and should now yield its place to those special Societies it has served to call into existence. On the other hand, it may be urged that the brilliant success of last year's Anniversary Meeting, enhanced by the comprehensive address delivered on that occasion by my distinguished predecessor in office, Sir John Lubbock, has proved, at least, that the British Association is not dead in the affection of its members, and it behoves us at this, the first ordinary gathering in the second half-century, to consider what are the strong points to rely upon for the continuance of a career of success and usefulness.

If the facilities brought home to our doors of acquiring scientific information have increased, the necessities for scientific

enquiry have increased in a greater ratio. The time was when science was cultivated only by the few, who looked upon its application to the arts and manufactures as almost beneath their consideration; this they were content to leave in the hands of others, who, with only commercial aims in view, did not aspire to further the objects of science for its own sake, but thought only of benefiting by its teachings. Progress could not be rapid under this condition of things, because the man of pure science rarely pursued his enqniry beyond the mere enunciation of a physical or chemical principle, whilst the simple practitioner was at a loss how to harmonise the new knowledge with the stock of information which formed his mental capital in trade.

The advancement of the last fifty years has, I venture to submit, rendered theory and practice so interdependent that an intimate union between them is a matter of absolute necessity for our future progress. Take, for instance, the art of dyeing, and we find that the discovery of new colouring matters derived from waste products, such as coal-tar, completely changes its practice, and renders an intimate knowledge of the science of chemistry a matter of absolute necessity to the practitioner. In telegraphy and in the new arts of applying electricity to lighting, to the transmission of power, and to metallurgical operations, problems arise at every turn requiring for their solution not only an intimate acquaintance with, but a positive advance upon, electrical science, as established by purely theoretical research in the laboratory. In general engineering the mere practical art of constructing a machine so designed and proportioned as to produce mechanically the desired effect, would suffice no longer. Our increased knowledge of the nature of the mutual relations between the different forms of energy makes us see clearly what are the theoretical limits of effect; these, although beyond our absolute reach, may be looked upon as the asymptotes to be approached indefinitely by the hyperbolic course of practical progress, of which we should never lose sight. Cases arise, moreover, where the introduction of new materials of construction, or the call for new effects, renders former rules wholly insufficient. In all these cases practical knowledge has to go hand in hand with the advanced science in order to accomplish the desired end.

Far be it from me to think lightly of the ardent students of nature, who, in their devotion to research, do not allow their minds

to travel into the regions of utilitarianism and of self-interest. These, the high priests of science, command our utmost admiration; but it is not to them that we can look for our current progress in practical science, much less can we look for it to "the thumb" practitioner, who is guided by what comes nearer to instinct than to reason. It is to the man of science, who also gives attention to practical questions, and to the practitioner, who devotes part of his time to the prosecution of strictly scientific investigations, that we owe the rapid progress of the present day, both merging more and more into one class, that of pioneers in the domain of nature. It is such men that Archimedes must have desired when he refused to teach his disciples the art of constructing his powerful ballistic engines, exhorting them to give their attention to the principles involved in their construction; and that Telford, the founder of the Institution of Civil Engineers, must have had in his mind's eye, when he defined civil engineering as "the art of directing the great sources of nature."

These considerations may serve to show that although we see the men of both abstract and applied science group themselves in minor bodies for the better prosecution of special objects, the points of contact between the different branches of knowledge are ever multiplying, all tending to form part of a mighty tree—the tree of modern science, under whose ample shadow its cultivators will find it both profitable and pleasant to meet, at least once a year; and considering that this tree is not the growth of one country only, but spreads both its roots and branches far and wide, it appears desirable that at these yearly gatherings other nations should be more fully represented than has hitherto been the case. The subjects discussed at our meetings are without exception of general interest, but many of them bear an international character, such as the systematic collection of magnetic, astronomical, meteorological, and geodetical observations, the formation of a universal code for signaling at sea, and for distinguishing lighthouses, and especially the settlement of scientific nomenclatures and units of measurement, regarding all of which an international accord is a matter of the utmost practical importance.

As regards the measures of length and weight it is to be regretted that this country still stands aloof from the movement initiated in France towards the close of last century: but, con-

sidering that in scientific work metrical measure is now almost universally adopted, and that its use has been already legalised in this country, I venture to hope that its universal adoption for commercial purposes will soon follow as a matter of course. The practical advantages of such a measure to the trade of this country would, I am convinced, be very great, for English goods, such as machinery or metal rolled to current sections, are now almost excluded from the Continental market, owing to the unit measure employed in their production. The principal impediment to the adoption of the metre consists in the strange anomaly that although it is legal to use that measure in commerce, and although a copy of the standard metre is kept in the Standards' Department of the Board of Trade, it is impossible to procure legalised rods representing it, and to use a non-legalised copy of a standard in commerce is deemed fraudulent. Would it not be desirable that the British Association should endeavor to bring about the use in this country of the metre and kilogramme, and, as a preliminary step, petition the Government to be represented on the International Metrical Commission, whose admirable establishment at Sèvres possesses, independently of its practical work, considerable scientific interest, as a well found laboratory for developing methods of precise measurement.

Next in importance to accurate measures of length, weight, and time, stand, for the purposes of modern science, those of electricity.

The remarkably clear lines separating conductors from non-conductors of electricity, and magnetic from non-magnetic substances, enable us to measure electrical quantities and effects with almost mathematical precision; and, although the ultimate nature of this, the youngest scientifically investigated form of energy, is yet wrapt in mystery, its laws are the most clearly established, and its measuring instruments (galvanometres, electrometers and magnetometers), are amongst the most accurate in physical science. Nor could any branch of science or industry be named in which electrical phenomena do not occur, to exercise their direct and important influence.

If, then, electricity stands foremost amongst the exact sciences, it follows that its unit measures should be determined with the utmost accuracy. Yet, twenty years ago, very little advance had been made towards the adoption of a rational system. Ohm had, it is true, given us the fixed relations existing between

electromotive force, resistance, and quantity of current; Joule had established the dynamical equivalent of heat and electricity, and Gauss and Weber had proposed their elaborate system of absolute magnetic measurement. But these invaluable researches appeared only as isolated efforts, when, in 1862, the Electric Unit Committee was appointed by the British Association, at the instance of Sir William Thomson, and it is to the long-continued activity of this Committee that the world is indebted for a consistent and practical system of measurement, which, after being modified in details, received universal sanction last year by the International Electrical Congress assembled at Paris.

At this Congress, which was attended officially by the leading physicists of all civilised countries, the attempt was successfully made to bring about a union between the statical system of measurement that had been followed in Germany and some other countries, and the magnetic or dynamical system developed by the British Association, also between the geometrical measure of resistance, the (Werner) Siemens unit, that had been generally adopted abroad, and the British Association unit intended as a multiple of Weber's absolute unit, though not entirely fulfilling that condition. The Congress, while adopting the absolute system of the British Association, referred the final determination of the unit measure of resistance to an International Committee, to be appointed by the representatives of the several governments: they decided to retain the mercury standard for reproduction and comparison, by which means the advantages of both systems are happily combined, and much valuable labor is utilised; only, instead of expressing electrical quantities directly in absolute measure, the Congress has embodied a consistent system, based on the Ohm, in which the units are of a value convenient for practical measurements. In this, which we must hereafter know as the "practical system," as distinguished from the "absolute system," the units are named after leading physicists, the Ohm, Ampère, Volt, Coulomb, and Farad.

I would venture to suggest that two other units might, with advantage, be added to the system decided on by the International Congress at Paris. The first of these is the unit of magnetic quantity or pole. It is of some importance, and few will regard otherwise than with satisfaction the suggestion of Clausius that the unit should be called a "Weber," thus retaining a name most closely connected with electrical measurements, and

only omitted by the Congress in order to avoid the risk of confusion in the magnitude of the unit current with which his name had been formerly associated.

The other unit I should suggest adding to the list is that of power. The power conveyed by an Ampère through the difference of potential of a Volt is the unit consistent with the practical system. It might be appropriately called a Watt, in honor of that master mind in mechanical science, James Watt. He it was who first had a clear physical conception of power, and gave a rational method of measuring it. A Watt, then, expresses the rate of an Ampère multiplied by a Volt, whilst a horse-power is 746 Watts, and a Cheval de Vapeur 735.

The system of electro-magnetic units would then be :—

(1)	Weber, the unit of	magnetic	quantity	$=10^8$
(2)	Ohm, "	"	resistance	$=10^9$
(3)	Volt. "	"	electro-motive force	$=10^8$
(4)	Ampère, "	"	current	$=10^{-1}$
(5)	Coulomb, "	"	quantity	$=10^{-1}$
(6)	Watt "	"	power	$=10^7$
(7)	Farad "	"	capacity	$=10^{-9}$

Electricity is the form of energy best suited for transmitting an effect from one place to another: the electric current passes through certain substances—the metals—with a velocity limited only by the retarding influence caused by electric charge of the surrounding dielectric, but approaching probably under favorable conditions that of radiant heat and light, or 300,000 kilometres per second; it refuses, however, to pass through oxidised substances, glass, gums, or through gases except when in a highly rarified condition. It is easy therefore to confine the electric current within bounds, and to direct it through narrow channels of extraordinary length. The conducting wire of an Atlantic cable is such a narrow channel; it consists of a copper wire, or strand of wires, 5 m. m. in diameter, by nearly 5000 kilometres in length, confined electrically by a coating of guttapercha about 4 m. m. in thickness. The electricity from a small galvanic battery passing into this channel prefers the long journey to America in the good conductor, and back through the earth, to the shorter journey across the 4 m. m. in thickness of insulating material. By an improved arrangement the alternating currents employed to work long submarine cables do not actually complete the circuit, but are merged in a condenser at the receiving

station, after having produced their extremely slight but certain effect upon the receiving instrument. So perfect is the channel and so precise the action of both the transmitting and receiving instruments employed, that two systems of electric signals may be passed simultaneously through the same cable in opposite directions, producing independent records at either end. By the application of this duplex mode of working to the direct United States cable under the superintence of Dr. Muirhead, its transmitting power was increased from twenty-five to sixty words a minute, being equivalent to about twelve currents or primary impulses per second.

The minute currents here employed are far surpassed as regards delicacy and frequency by those revealed to us by that marvel of the present day, the telephone. The electric currents caused by the vibrations of a diaphragm acted upon by the human voice, naturally vary in frequency and intensity according to the number and degree of those vibrations, and each motor current in exciting the electro-magnet forming part of the receiving instrument, deflects the iron diaphragm occupying the position of an armature to a greater or smaller extent according to its strength. Savart found that the fundamental *la* springs from 440 complete vibrations in a second; but what must be the frequency and modulations of the motor current and of magnetic variations necessary to convey to the ear through the medium of a vibrating armature, such a complex of human voices and of musical instruments as constitutes an opera performance. And yet such performances could be distinctly heard and even enjoyed as an artistic treat by supplying to the ear a pair of the double telephonic receivers, at the Paris Electrical Exhibition, when connected with a pair of transmitting inrtruments in front of the foot lights of the Grand Opera. In connection with the telephone, the names of Reiss, Graham Bell, Edison, and Hughes will ever be remembered.

Regarding the transmission of power to a distance the electric current has now entered the lists in competion with compressed air, the hydraulic accumulator, and the quick running rope as used at Schaffhausen to utilise the power of the Rhine fall. The transformation of electrical into mechanical energy can be accomplished with no further loss than is due to such incidental causes as friction and the heating of wires; these in a properly designed dynamo-electric machine do not exceed 10 per cent. as

shown by Dr. John Hopkinson, and, judging from recent experiments of my own, a still nearer approach to ultimate success is attainable. Adhering, however, to Dr. Hopkinson's determination, for safety's sake, and assuming the same percentage in re-converting the current into mechanical effect, a total loss of 19 per cent results. To this loss must be added that through electrical resistance in the connecting line wires, which depends upon their length and conductivity, and that due to heating by friction of the working parts of the machine. Taking these as being equal to the internal losses incurred in the double process of conversion, there remains a useful effect of 100–38=62 per cent, attainable at a distance, which agrees with experimental results, although in actual practice it would not be safe at present to expect more than 50 per cent of ultimate useful effect, to allow for all mechanical losses.

In using compressed air or water for the transmission of power the loss cannot be taken at less than 50 per cent, and as it depends upon fluid resistance, it increases with distance more rapidly than in the case of electricity. Taking the loss of effect in all cases at 50 per cent, electric transmission presents the advantage that an insulated wire does the work of a pipe capable of withstanding high internal pressure, which latter must be more costly to put down and to maintain. A second metallic conductor is required, however, to complete the electrical circuit, as the conducting power of the earth alone is found unreliable for passing quantity currents, owing to the effect of polarisation; but as this second conductor need not be insulated, water or gas pipes, railway metal or fencing wire, may be called into requisition for the purpose. The small space occupied by the electromotor, its high working speed, and the absence of waste products, render it specially available for the general distribution of power to cranes and light machinery of every description. A loss of effect of 50 per cent does not stand in the way of such applications, for it must be remembered that a powerful central engine of best construction produces motive power with a consumption of two pounds of coal per horse-power per hour, whereas small engines distributed over a district would consume not less than five; we thus see that there is an advantage in favor of electric transmission as regards fuel, independently of the saving of labor and other collateral benefits.

To agriculture electric transmission of power seems adapted

for effecting the various operations of the farm and the fields from one centre. Having worked such a system myself in combination with electric lighting and horticulture for upwards of two years, I can speak with confidence of its economy, and of the facility with which the work is accomplished in charge of untrained persons.

As regards the effect of electric light upon vegetation there is little to add to what was stated in my paper read before Section A last year, and ordered to be printed with the Report, except that in experimenting upon wheat, barley, oats, and other cereals sown in open air, there was a marked difference between the growth of the plants influenced and uninfluenced by the electric light. This was not very apparent until towards the end of February, when with the first appearance of mild weather the plants under the influence of an electric lamp of 4000 candle-power placed about 5 metres above the surface, developed with extreme rapidity, so that by the end of May they stood above 4 feet high, with the ears in full bloom, when those not under its influence were under 2 feet in height, and showed no sign of the ear.

In the electric railway first constructed by Dr. Werner Siemens, at Berlin, in 1879, electric energy was transmitted to the moving carriage or train of carriages through the two rails upon which it moved, these being sufficiently insulated from each other by being placed upon well creosoted cross sleepers. At the Paris Electric Exhibition the current was conveyed through two separate conductors making sliding or rolling contact with the carriage, whereas in the electric railway now in course of construction in the north of Ireland (which, when completed, will have a length of twelve miles), a separated conductor will be provided by the side of the railway, and the return circuit completed through the rails themselves, which in that case need not be insulated; secondary batteries will be used to store the surplus energy created in running downhill, to be restored in ascending steep inclines, and for passing railways where the separate insulated conductor is not practicable. The electric railway possesses great advantages over horse or stream power for towns, in tunnels and in all cases where natural sources of energy, such as waterfalls, are available; but it would not be reasonable to suppose that it will in its present condition compete with steam propulsion upon ordinary railways.

The deposition of metals from their solutions is perhaps the oldest of all useful applications of the electric current, but it is only in very recent times that the dynamic current has been practically applied to the refining of copper and other metals, as now practised in Birmingham and elsewhere, and upon an exceptionally large scale at Ocker, in Germany. The dynamo machine there employed was exhibited at the Paris Electrical Exhibition, its peculiar feature being that the conductors upon the rotating armature consisted of solid bars of copper 30 m. m. square, in section, which were found only just sufficient to transmit the large quantity of low tension necessary for this operation. One such machine consuming 4-horse power deposits about 300 kilogrammes of copper per 24 hours; the motive power at Ocker is derived from a waterfall.

The electric energy may also be employed for heating purposes, but in this case it would obviously be impossible for it to compete in point of economy with the direct combustion of fuel for the attainment of ordinary degrees of heat. Bunsen and Ste.-Claire De Ville have taught us, however, that combustion becomes extremely sluggish when a temperature of 1800° C. has been reached, and for effects of temperatures exceeding that limit the electric furnace will probably find advantageous applications. Its specific advantage consists in being apparently unlimited in the degree of heat attainable, thus opening out a new field of investigation to the chemist and metallurgist. Tungsten has been melted in such a furnace, and 8 pounds of platinum have been reduced from the cold to the liquid condition in 20 minutes.

The largest and most extensive application of electric energy at the present is to lighting; but, considering how much has of late been said and written for and against this new illuminant, I shall here confine myself to a few general remarks.

The principal argument in favor of the electric light is furnished by its immunity from products of combustion which not only heat the lighted appartments, but substitute carbonic acid and deleterious sulphur compounds for the oxygen upon which respiration depends; the electric light is white instead of yellow, and thus enables us to see pictures, furniture, and flowers as by daylight; it supports growing plants instead of poisoning them, and by its means we can carry on photography and many other industries at night as well as during the day. The objection

frequently urged against the electric light, that it depends upon the continuous motion of steam or gas engines, which are liable to accidental stoppage, has been removed by the introduction into practical use of the secondary battery; this, although not embodying a new conception, has lately been greatly improved in power and constancy by Planté, Faure, Volckmar, Sellon, and others, and promises to accomplish for electricy what the gas-holder has done for the supply of gas, and the accumulator for hydraulic transmission of power.

It can no longer be a matter of reasonable doubt, therefore, that electric light will take its place as a public illuminant, and that even should its cost be found greater than that of gas, it will be preferred for lighting drawing-rooms, theatres and concert-rooms, museums, churches, warehouses, show-rooms, printing establishments and factories, and also the cabins and engine-rooms of passenger steamers. In the cheaper and more powerful form of the arc light, it has proved itself superior to any other illuminant for spreading artificial daylight over the large areas of harbors, railway stations, and the sites of public works. When placed within a holophote the electric lamp has already become auxiliary in effecting military operations both by sea and land.

The electric light may be worked by natural sources of power, such as waterfalls, the tidal wave, or the wind, and it is conceivable that these may be utilised at considerable distances by means of metallic conductors. Some five years ago I called attention to the vastness of those sources of energy, and the facility offered by electric conduction in rendering them available for lighting and power-supply, while Sir William Thomson made this important matter the subject of his admirable address to Section A last year at York, and dealt with it in an exhaustive manner.

The advantages of the electric light and of the distribution of power by electricity have lately been recognised by the British Government, who have just passed a Bill through Parliament to facilitate the establishment of electric conductors in towns, subject to certain regulating clauses to protect the interests of the public and of local authorities. Assuming the cost of electric light to be practically the same as gas, the preference for one or other will in each application be decided upon grounds of relative convenience, but I venture to think that gas-lighting will hold its own as the poor man's friend.

Gas is an institution of the utmost value to the artisan; it requires hardly any attention, is supplied upon regulated terms, and gives with what should be a cheerful light a genial warmth, which often saves the lighting of a fire. The time is moreover not far distant, I venture to think when both rich and poor will largely resort to gas as the most convenient, the cleanest, and the cheapest of heating agents, and when raw coal will be seen only at the colliery or the gasworks. In all cases where the town to be supplied is within say 30 miles of the colliery, the gasworks may with advantage be planted at the mouth, or still better at the bottom of the pit, whereby all haulage of fuel would be avoided, and the gas, in its ascent from the bottom of the colliery, would require an onward pressure sufficient probably to impel it to its destination. The possibility of transporting combustible gas through pipes for such a distance has been proved at Pittsburg, where natural gas from the oil districts is used in large quantities.

The quasi monopoly so long enjoyed by gas companies has had the inevitable effect of checking progress. The gas being supplied by meter, it has been seemingly to the advantage of the companies to give merely the prescribed illuminating power, and to discourage the invention of economical burners, in order that the consumption might reach a maximum. The application of gas for heating purposes has not been encouraged, and is still made difficult in consequence of the objectionable practice of reducing the pressure in the mains during daytime to the lowest possible point consistent with prevention of atmospheric indraught. The introduction of electric light has convinced gas managers and directors that such a policy is no longer tenable, but must give way to one of technical progress; new processes for cheapening the production and increasing the purity and illuminating power of gas are being fully discussed before the Gas Institute; and improved burners, rivalling the electric light in brilliancy, greet our eyes as we pass along our principal thoroughfares.

Regarding the importance of gas supply as it exists at present, we find from a Government return that the capital invested in gasworks in England, other than those of local authorities, amounts to £30,000,000; in these 4,281,048 tons of coal are converted annually, producing 43,000 million cubic feet of gas, and about 2,800,000 tons of coke: whereas the total amount of coal annually converted in the United Kingdom may be estima-

ted at 9,000,000 tons, and the by-products therefrom at 500,000 tons of tar, 1,000,000 tons of ammonia liquor, and 4,000,000 tons of coke, according to the returns kindly furnished me by the managers of many of the gasworks and corporations. To these may be added say 120,000 tons of sulphur, which up to the present time is a waste product.

Previous to the year 1856—that is to say before Mr. W. H. Perkin had invented his practical process, based chiefly upon the theoretical investigations of Hofmann, regarding the coal-tar bases and the chemical constitution of indigo—the value of coal-tar in London was scarcely a halfpenny a gallon, and in country places gas makers were glad to give it away. Up to that time the coal-tar industry had consisted chiefly in separating the tar by distillation into naphtha, creosote, oils, and pitch. A few distillers, however, made small quantities of benzene, which had been first shown—by Mansfield, in 1849—to exist in coal-tar naptha mixed with toluene, cumene, &c. The discovery, in 1856, of the mauve or aniline purple gave a great impetus to the coal-tar trade, inasmuch as it necessitated the separation of large quantities of benzene, or a mixture of benzene and toluene, from the naphtha. The trade was further increased by the discovery of the magenta of rosaniline dye, which required the same products for its preparation. In the meantime, carbolic acid was gradually introduced into commerce, chiefly as a disinfectant, but also for the production of coloring matter.

The color industry utilises even now practically all the benzene, a large proportion of the solvent naphtha, all the anthracene, and a portion of the naphthaline resulting from the distillation of coal-tar; and the value of coloring matter thus produced is estimated by Mr. Perkin at £3,350,000.

The demand for ammonia may be taken as unlimited, on account of its high agricultural value as a manure; and, considering the failing supply of guano and the growing necessity of stimulating the fertility of our soil, an increased production of ammonia may be regarded as a matter of national importance, for the supply of which we have to look almost exclusively to our gas-works. The present production of 1,000,000 tons of liquor yields 95,000 tons of sulphate of ammonia; which, taken at £20 10s. a ton, represents an annual value £1,947,000.

The total annual value of the gas-works by-products may be estimated as follows:—

Coloring matter	£3,350,000
Sulphate of ammonia	1,947,000
Pitch (355,000 tons)	365,000
Creosote (25,000 gallons)	208,000
Crude carbolic acid (1,000,000 gallons)	100,000
Gas coke, 4,000,000 tons (after allowing 2,000,000 consumption in working the retorts) at 12s	2,400,000
	£8,370,000

Taking the coal used, 9,000,000 tons, at 12s., equal £5,400,000, it follows that the by-products exceed in value the coal used by very nearly £3,000,000.

In using raw coal for heating purposes these valuable products are not only absolutely lost to us, but in their stead we are favoured with those semi-gaseous by-products in the atmosphere too well known to the denizens of London and other large towns as smoke. Prof. Roberts has calculated that the soot in the pall hanging over London on a winter's day amounts to fifty tons, and that the carbonic oxide, a poisonous compound, resulting from the imperfect combustion of coal, may be taken as at least five times that amount. Mr. Aitken has shown, moreover, in an interesting paper communicated to the Royal Society of Edinburgh last year, that the fine dust resulting from the impecfect combustion of coal is mainly instrumental in the formation of fog; each particle of solid matter attracting to itself aqueous vapour; these globules of fog are rendered particularly tenacious and disagreeable by the presence of tar vapour, another result of imperfect combustion of raw fuel, which might be turned to much better account at the dye-works. The hurtful influence of smoke upon public health, the great personal discomfort to which it gives rise, and the vast expense it indirectly causes through the destruction of our monuments, pictures, furniture, and apparel, are now being recognized, as is evidenced by the success of recent Smoke Abatement Exhibitions. The most effectual remedy would result from a general recognition of the fact that wherever smoke is produced fuel is being consumed wastefully, and that all our caloric effects, from the argest down to the domestic fire, can be realised as completely,

and more economicaly, without allowing any of the fuel employed to reach the atmosphere unburnt. This most desirable result may be effected by the use of gas for all heating purposes with or without the addition of coke or anthracite.

The cheapest form of gas is that obtained through the entire distillation of fuel in such gas producers as are now largely used in working the furnaces of glass, iron, and steel works; but gas of this description would not be available for the supply of towns owing to its bulk, about two-thirds of its volume being nitrogen. The use of water-gas, resulting from the decomposition of steam in passing through a hot chamber filled with coke, has been suggested, but this gas also is objectionable, because it contains, besides hydrogen, the poisonous and inodorous gas carbonic oxide, the introduction of which into dwelling-houses could not be effected without considerable danger. A more satisfactory mode of supplying heating separately from illuminating gas would consist in connecting the retort at different periods of the distillation with two separate systems of mains for the delivery of the respective gases. By resorting to improved means of heating the retorts with gaseous fuel, such as have been in use at the Paris gas-works for a considerable number of years, the length of time for effecting each distillation may be shortened from six hours, the usual period in former years, to four, or even three hours, as now practised at Glasgow and elsewhere. By this means a given number of retorts can be made to produce, in addition to the former quantity of illuminating gas of superior quality, a similar quantity of heating gas, resulting in a diminished cost of production, and an increased supply of the valuable by-products previously referred to.

The greater efficiency of gas as a fuel results chiefly from the circumstance that a pound of gas yields in combustion 22,000 heat units, or exactly double the heat produced in the combustion of a pound of ordinary coal. This extra heating power is due partly to the freedom of the gas from earthy constituents, but chiefly to the heat imparted to it in effecting its distillation. Recent experiments with gas-burners have shown that in this direction also there is much room for improvement.

The amount of light given out by a gas flame depends upon the temperature to which the particles of solid carbon in the flame are raised, and Dr. Tyndall has shown that of the radiant energy set up in such a flame, only the 1-25th part

is luminous; the hot products of combustion carry off at least four times as much energy as is radiated, so that no more than one-hundredth part of the heat evolved in combustion is converted into light. This proportion could be improved, however, by increasing the temperature of combustion, which may be effected either by intensified air-current or by regenerative action. Supposing that the heat of the products of combustion could be communicated to metallic surfaces, and be transferred by conduction or otherwise to the atmospheric air supporting combustion in the flame, we should be able to increase the temperature accumulatively to any point within the limit of dissociation; this limit may be fixed at about 2300° C., and cannot be very much below that of the electric arc. At such a temperature the proportion of luminous rays to the total heat produced in combustion would be more than doubled, and the brilliancy of the light would at the same time be greatly increased. Thus improved, gas-lighting may continue its rivalry with electric lighting both as regards economy and brilliancy, and such rivalry must necessarily result in great public advantage.

In the production of mechanical effect from heat, gaseous fuel also presents most striking advantages, as will appear from the following consideration. When we have to deal with the question of converting mechanical into electrical effect, or *vice versa*, by means of the dynamo-electrical machine, we have only to consider what are the equivalent values of the two forms of energy, and what precautions are necessary to avoid losses by the electrical resistance of conductors and by friction. The transformation of mechanical effect into heat involves no losses except those resulting from imperfect installation, and these may be co completely avoided that Dr. Joule was able by this method to determine the equivalent values of the two forms of energy. But in attempting the inverse operation of effecting the conversion of heat into mechanical energy, we find ourselves confronted by the second law of thermo-dynamics, which says that whenever a given amount of heat is converted into mechanical effect, another but variable amount descends from a higher to a lower potential, and is thus rendered unavailable.

In the condensing steam-engine this waste heat comprises that communicated to the condensing water, whilst the useful heat, or that converted into mechanical effect, depends upon the difference of temperature between the boiler and condenser. The

boiler pressure is limited, however, by considerations of safety and convenience of construction, and the range of working temperature rarely exceeds 120° C. except in the engines constructed by Mr. Perkins, in which a range of 160° C., or an expansive action commencing at 14 atmospheres, has been adopted with considerable promise of success, as appears from an able report on this engine by sir Frederick Bramwell. To obtain more advantageous primary conditions we have to turn to the caloric or gas-engine, because in them the co-efficient of efficiency expressed by $\frac{T-T'}{T}$, may be greatly increased. The value would reach a minimum if the initial absolute temperature T could be raised to that of combustion, and T' reduced to atmospheric temperature, and these maximum limits can be mnch more nearly approached in the gas-engine worked by a combustible mixture of air and hydrocarbons than in the steam-engine.

Before many years have elapsed we shall find in our factories and on board ships engines with a fuel consumption not exceeding 1 pound of coal per effective horsepower per hour, in which the gas producer takes the place of the somewhat complex and dangerous steam-boiler. The advent of such an engine and of the dynamo-machine must mark a new era of material progress at least equal to that produced by the introduction of steam power in the early part of our century.

When the British Association met at Southampton on a former occasion, Schönbein announced to the world his discovery of gun-cotton. This discovery has led the way to many valuable researches on explosives generally, in which Mr. Abel has taken a leading part.

. . . .

The extraordinary difference of condition, before and after its ignition, of such matter as constitutes an explosive agent, leads up to the consideration of the aggregate state of matter under other circumstances. As early as 1776 Alexander Volta observed that the volume of glass was changed under the influence of electrification, by what he termed electrical pressure. Dr. Kerr, Govi, and others have followed up the same inquiry, which is at present continued chiefly by Dr. George Quincke, of Heidelberg. who finds that temperature, as well as chemical constitution of the dielectric under examination, exercises a determining influence upon the amount and charcter of the change of volume

effected by electrification; that the change of volume may under certain circumstances be effected instantaneously as in flint glass, or only slowly as in crown glass, and that the elastic limit of both is dimished by electrification, whereas in the case of mica and of gutta-percha an increase of elasticity takes place.

Still greater strides are being made at the present time towards a clearer perception of the condition of matter when particles are left some liberty to obey individually the forces brought to bear upon them. By the discharge of high tension electricity through tubes containing highly rarified gases (Geissler's tubes), phenomena of discharge were produced which were at once most striking and suggestive. The Sprengel pump afforded a means of pushing the exhaustion to limits which had formerly been scarcely reached by the imagination. At each step the condition of attenuated matter revealed varying properties when acted upon by artificial discharge and magnetic force. The radiometer of Crookes imported a new feature into these inquiries, which at the present time occupy the attention of leading physicists in all countries.

The means usually employed to produce electrical discharge in vacuum tubes was Ruhmkorff's coil; but Mr. Gassiot first succeeded in obtaining the phenomena by means of a galvanic battery of 3000 Leclanché cells. Dr. de la Rue, in conjunction with his friend, Dr. Hugo Müller,, has gone far beyond his predecessors in the production of batteries of high potential. At his lecture "On the Phenomena of Electric Discharge," delivered at the Royal Institution in January, 1881, he employed a battery of his invention consisting of 14,400 cells (14,832 Volts), which gave a current 0·054 Ampère, and produced a discharge at a distance of 0.71 inch between the terminals. During last year he increased the number of cells to 15,000 (15,450 Volts), and increased the current to 0·4 Ampère, or eight times that of the battery he used at the Royal Institution.

On the occasion of his lecture, Dr. de la Rue produced, in a very large vacuum tube, an imitation of the Aurora Borealis; and he has deduced from his experiments that the greatest brilliancy of Aurora displays must be at an altitude of from 37 to 38 miles—a conclusion of the highest interest, and in opposition to the extravagant estimate of 281 miles at which it had been previously put.

The President of the Royal Society has made the phenomena

of electrical discharge his study for several years, and resorted in his important experiments to a special source of electric power. In a note addressed to me, Dr. Spottiswoode describes the nature of his investigations much more clearly than I could venture to give them. He says: "It had long been my opinion that the dissymmetry shown in electrical discharges through rarified gases must be an essential element of every disruptive discharge, and that the phenomena of stratification might be regarded as magnified images of features always present, but concealed under ordinary circunstances." It was with a view to the study of this question that the researches by Moulton and myself were undertaken. The method chiefly used consisted in introducing into the circuit intermittence of a particular kind, whereby one luminous discharge was rendered sensitive to the approach of a conductor outside the tube. The application of this method enabled us to produce artificially a variety of phenomena, including that of stratification. We were thus led to a series of conclusions relating to the mechanism of the discharge, among which the following may be mentioned:

"1. That a stria, with its attendant dark space, forms a physical unit of a striated discharge.

2. That the origin of the luminous column is to be sought for at its negative end; that the luminosity is an expression of a demand for negative electricity.

3. That the time occupied by electricity of either name in traversing a tube is greater than that occupied in traversing an equal length of wire, but less than that occupied by molecular streams (Crooke's radiations) in traversing the tubes.

4. That the brilliancy of the light with so little heat may be due in part to brevity in the duration of the discharge.

5. That striæ are not merely loci in which electrical is converted into luminous energy, but are actual aggregations of matter.

This last conclusion was based mainly on experiments made with an induction coil excited in a new way,—viz., directly by an alternating machine, without the intervention of a commutator or condenser. This mode of excitement promises to be one of great importance in spectroscopic work, as well as in the study of the discharge in a magnetic field, partly on account of the simplification which it permits in the construction of induction coils, but mainly on account of the very great increase of strength in the secondary currents to which it gives rise."

These investigations assume additional importance when we view them in connection with solar—I may even say stellar—physics, for evidence is augmenting in favor of the view that interstellar space is not empty, but is filled with highly attenuated matter of such a nature as may be put into our vacuum tubes. Nor can the matter occupying stellar space be said to be any longer beyond our reach for chemical and physical test. The spectroscope has already thrown a flood of light upon the chemical constitution and physical condition of the sun, the stars, the comets, and the far distant nebulæ, which have yielded spectroscopic photographs under the skilful management of Dr. Huggins, and Dr. Draper, of New York. Armed with greatly improved apparatus the physical astronomer has been able to reap a rich harvest of scientific information during the short periods of the last two solar eclipses; that of 1879, visible in America, and that of May last, observed in Egyyt by Lockyer, Schuster, and by Continental observers of high standing. The result of this last eclipse expedition has been summed up as foliows: "Different temperature levels have been discovered in the solar atmosphere; the constitution of the corona has now the possbility of being determined, and it is proved to shine with its own light. A suspicion has been aroused once more as to the existence of the lunar atmosphere, and the position of an important line has been discovered. Hydrocarbons do not exist close to the sun, but may in space between us and it."

To me personally these reported results possess peculiar interest, for in March last I ventured to bring before the Royal Society a speculation regarding the conservation of solar energy, which was based upon the three following postulates, viz.:—

1. That aqueous vapour and carbon compounds are present in stellar or interplanetary space.

2. That these gaseous compounds are capable of being dissociated by radiant solar energy while in a state of extreme attenuation.

3. That the effect of solar rotation is to draw in dissociated vapors upon the polar surfaces, and to eject them after combustion has taken place back into space equatorially.

It is therefore a matter of peculiar gratification to me that the results of observation here recorded give considerable support to that speculation. The luminous equatorial extensions of the sun

which the American observations revealed in such a striking manner (with which I was not acquainted when writing my paper), were absent in Egypt; but the outflowing equatorial streams I suppose to exist could only be rendered visible by reflected sunlight, when mixed with dust produced by exceptional solar disturbances or by electric discharge; and the occasional appearance of such luminous extensions would serve only to disprove the hypothesis entertained by some, that they are divided planetary matter, in which case their appearance should be permanent. Professor Langley, of Pittsburg, has shown by means of his Bolometer, that the solar actinic rays are absorbed chiefly in the solar as in the terrestrial atmosphere, and Captain Abney has found by this new photometric method that absorption due to hydrocarbons takes place somewhere between the solar and the terrestrial atmosphere; in order to test this interesting result still further, he has lately carried his apparatus to the top of the Riffel with the view of diminishing the amount of territorial atmospheric air between it and the sun, and intends to bring a paper on this subject before Section A. Stellar space filled with such matter as hydro-carbon and aqueous vapour would establish a material continuity between the sun and his planets, and between the innumerable solar systems of which the universe is composed. If chemical action and reaction can further be admitted, we may be able to trace certain conditions of thermal dependence and maintenance, in which we may recognise principles of high perfection, applicable also to comparatively humble purposes of humble life.

We shall thus find that in the great workshop of nature there are no lines of demarcation to be drawn between the most exalted speculation and common-place practice, and that all knowledge must lead up to one great result, that of an intelligent recognition of the Creator through His works. So then, we members of the British Association and fellow-workers in every branch of science may exhort one another in the words of the American bard who has so lately departed from amongst us:—

Let us then be up and doing,
With a heart for any fate;
Still achieving, still pursuing,
Learn to labour and to wait.

ON THE PRESENT PHASE OF THE ANTIQUITY OF MAN.

By W. Boyd Dawkins, M.A., F.R.S., F.G.S., F.S.A.

(Address delivered before the Anthropological Section of the British Association for ths Advancement of Science at Southampton. August, 1882.)

In taking the chair in this department of the biological section of the British Association, two courses lie open before me. I might give an address whivh should be a history of the progress of anthropology during the last year, or I might devote myself to some special branch. The swift developement of our young and rapidly growing science, which embraces within its scope all that is known, not merely about man, but about his environment, in present and past times, renders the first and more ambitious course peculiarly difficult to one, like myself, laboring under the pressure of many avocations. I am therefore driven to adopt the second and the easier, by choosing a subject with which I am familiar, and which appears to me to be appropriate in this place of meeting. I propose to place before you the present phase of the inquiry into the antiquity of man, and to point out what we know of the conditions of life—though our knowledge of them is imperfect and fragmentary—under which man has appeared in the Old and in the New Worlds. The rudely chipped implements left by the primeval hunters in the beds of gravel of Hampshire and Wiltshire, and along the shores of Southampton Water and elsewhere, are eloquent witnesses of the presence of man in this district, at a time when there was no Southampton Water, and the elephant and the reindeer wandered over the site of this busy mart of ships; when the Isle of Wight was not an island, and the River-drift hunter could walk across from Portsmouth to Cowes, with no obstacle excepting that offered by the rivers and morasses I propose to enter upon the labors of Prestwich, Evans, Stevens and Blackmore, Codrington, Read, Brown and other investigators in this country, and to combine the results of their inquiries with those in other countries, and with some observations of my own which I was able to make in 1880, during my visit to the United States.

THE LIMITATION OF THE INQUIRY.

The most striking feature in the study of the Tertiary period is the gradual and orderly succession of higher types of Mammalia, so well defined and so orderly, that I have used it as a

basis for the classification of the Tertiary period. We find the placental mammals becoming more and more specialised as we approach the frontier of history. The living orders appear in the Eocene, the living genera in the Meiocene, a few living species in the Pleiocene, and the rest in the Pleistocene. The characteristics of this evolution of living forms may be summed up in the following table:—

DEFINITION OF TERTIARY PERIOD BY PLACENTAL LAND MAMMALS.

VI. Historic; in which the events are recorded in history.	Events included in history.	Founded on discoveries, documents, refuse heaps, caves, tombs.
V. Prehistoric; in which domestic animals and cultivated fruits appear.	Man abundant; domestic animals, cultivated fruits, spinning, weaving, pottery - making, mining, commerce; the neolithic, bronze, and iron stages of culture.	Camps, habitations, refuse heaps, surface accumulations, caves alluvia, peat - bogs, submarine forests, raised beaches.
IV. Pleistocene; in which living species of placental mammals are more abundant than the extinct.	Man appears; *Anthropidæ*; the palæolithic hunter; living species abundant.	Refuse heaps, contents of caves, river deposits, submarine forests, boulder clay, moraines, marine sands, and shingle.
III. Pleiocene; in which living species of placental mammals appear.	Living species appear; apes, *Simiadæ*, in Southern Europe.	Fresh-water and marine strata; volcanic débris (Auvergne).
II. Meiocene; in which the alliance between living and placental mammals is more close than before.	Living genera appear; apes, *Simiadæ*, in Europe & North America.	Fresh-water and marine strata; volcanic débris (Auvergne); lignites.
I. Eocene; in which the placental mammals now on earth were represented by allied forms belonging to existing orders and families.	Living orders and families appear; lemurs (*Lemuridæ*) in Europe and North America.	Fresh-water and marine strata; lignites.

The orders, families, genera, and species in the above table, when traced forward in time, fall into shape in a geological tree, with its trunk hidden in the Secondary period, and its branch-

lets (the living species) passing upwards from the Pleiocene, a tree of life, with living Mammalia for its fruit and foilage. Were the extinct species taken into account, it would be seen that they fill up the intervals separating one living form from another, and that they too grow more and more like the living forms as they approach nearer to the present day. It must be remembered that in the above definitions the fossil marsupials are purposely ignored, because they began their specialisation in the Secondary period, and had arrived in the Eocene at the stage which is marked by the presence of a living genus—the opossum (*Didelphys*).

It will be seen from the examination of the above table, that our inquiry into the antiquity of man is limited to the last four of the divisions. The most specialised of all animals cannot be looked for until the higher Mammalia by which he is now surrounded were alive. We cannot imagine him in the Eocene age, at a time when animal life was not sufficiently differentiated to present us with any living genera of placental mammals. Nor is there any probability of his having appeared on the earth in the Meiocene, because of the absence of the higher placental mammals belonging to living species. It is most unlikely that man should have belonged to a fauna in which no other living species of mammal was present. He belongs to a more advanced stage of evolution than the mid-Meiocene of Thenay, as may be seen by a reference to the preceding table. Up to this time the evolution of the amimal kingdom had advanced no further than the Simadæ in the direction of man, and the apes then haunting the forests of Italy, France, and Germany, represent the highest type of those on earth.

We may also look at the question in another point of view. If man were upon the earth in the Meiocene age, it is incredible that he should not have become something else in the long lapse of ages, and during the chauges in the conditions of life by which all the Meiocene land Mammalia have been so profoundly affected, that they have been either exterminated, or have assumed new forms. It is impossible to believe that man should have been an exception to the law of change, to which all the higher Mammalia have been subjected since the Meiocene age.

Nor in the succeeding Pleiocene age can we expect to find man upon the earth, because of the very few living species of placental mammals then alive. The evidence brought forward by Professor

Capellinni, in favor of Pleiocene man in Italy, seems both to me and to Dr. Evans unsatisfactory, and that advanced by Professor Whitney in support of the existence of Pleiocene man in North America, cannot in my opinion be maintained. It is not until we arrive at the succeeding stage, or the Pleistocene, when living species of Mammalia begin to abound, that we meet with undisputable traces of the presence of man on the earth.

THE PLEISTOCENE PERIOD.

As a preliminary to our inquiry we must first of all define what is meant by the Pleistocene Period. It is the equivalent of the Quaternary of the French, and the Postpleiocene of the older works of Lyell, and it includes all the phenomena known in latitudes outside the Arctic Circle, where ice no longer is to be found, under the name glacial and inter-glacial. It is characterised in Europe, as I have pointed out in my work on "Early Man in Britain," by the arrival of living species, which may be conveniently divided into five groups, according to their present habitats. The first consists of those now found in the temperate zones of Europe, Asia, and North America. It includes the following animals:—

Mole, musk shrew, common shrew, mouse, beaver, hare, pika, pouched marmot, water-vole, red field-vole, short-tailed field-vole, Continental field-vole, lynx, wild cat, wolf, fox, marten, ermine, stoat, otter, brown bear, grisly bear, badger, horse, bison, urus, saiga antelope, stag, roe, fallow-deer, wild boar.

The second consists of animals of arctic habit:—

Russian vole, Norwegian lemming, arctic lemming, varying hare, musk sheep, reindoer, arctic fox, glutton.

The third is composed of those which enjoy the cold climate of the mountains:—

The Snowy vole, Alpine marmot, chamois, and ibex.

These animals invaded Europe from Asia, and as the cold increased, the temperate group found their way into Southern Europe and Northern Africa, while the arctic division pushed as far south as the Alps and Pyrenees.

The fourth group of invading forms is represented by animals now only found in warm countries:—

Porcupine, lion, panther, African lynx, Caffre cat, spotted hyena, striped hyena, and African elephant.

This group of animals is found as far to the north as York-

shire, and as far to the west as Ireland. Among the southern animals, too, must be reckoned the hippopotamus, which lived as far north as Britain in the Pleiocene age, and in the Pleistocene occurs in caves and river deposits, in intimate association with some arctic species, such as the reindeer.

The fifth group is composed of extinct species, hitherto unknown in Europe in the Pleistocene age, such as:—

The straight-tusked elephant, mammoth, the pigmy elephants, wooly and small-nose rhinoceroses, the Irish elk, pigmy hippopotamus, and the cave bear.

The question as to which of these groups the River-drift man belongs must be deferred till we can take a survey of the evidence elsewhere.

The early Pleistocene division is characterised by the presence of the temperate and southern species in Britain; the middle stage by the presence of the arctic, but not in full force; and the late Pleistocene by the abundance of arctic animals, not only in Britain, but on the Continent as far as the Alps and Pyrenees, and the lower valley of the Danube.

THE EARLY PLEISTOCENE FOREST AND MAMMALS OF EAST ANGLIA.

The first view which we get of the Pleistocene Mammalia in this country is offered by the accumulations associated with the buried forest of East Anglia. It extends for more than forty miles along the shores of Norfolk and Suffolk, from Cromer to Kessingland, passing into the cliff on the one hand and beneath the sea on the other. The forest was mainly composed of sombre Scotch firs and dark clustering yews, relieved in the summer by the lighter tinted foliage of the spruce and the oak, and in the winter by the silvery gleam of the birches, that clustered thickly with the alders in the marches, and stood out from a dense undergrowth of aloes and hazels. Among the animals living in this forest of the North Sea were species which haunted the valleys of the upper Seine at the time, such as the southern elephant, the Etruscan rhinoceros, the deer of the Carnutes, extinct horses, and the large extinct beaver. There were in addition to the shaggy-mained mammoth, the straight-tusked elephant, and the big-nosed rhinoceros. The stag, the roe, the Irish elk, were in the glades, Sedgwick's deer, with its many pointed antlers, the verticorn deer, and the gigantic urus. The undergrowth

formed a covert for the wild boar, and for beasts of prey, many in species and formidable in numbers, the cave bear, the hugest of its kind, the sabre-tooth lion, the wolf, the fox, and the wolverine. Among the smaller animals were to be noted the musk shrew, the common shrew, and a vole. In the trees were squirrels. Under foot the moles raised their hillocks of earth, and from between the lofty fronds of the Osmund royal beavers were to be seen building their lodges, and the hippopotamus as he emerged from the water and disappeared in the forest. Out of thirty species identified, no less than seventeen are living in some part of the world, and we have there obviously the stage in the evolution of mammalian life when the living species were becoming more abundant than the extinct. We may note, too, the absence of arctic animals in this fauna, more particularly of the reindeer.

The presence of these animals in Norfolk and Suffolk implies that at this time Britain was united to the Continent, and the presence of fossil species found in France indicate a southern extension of land in the direction of the Straits of Dover. The forest covered a large portion of the area of the North Sea, and in all probability the Atlantic seaboard was then at the 100-fathom line of the west coast of Ireland.

No traces of man have as yet been discovered in these deposits, although the large percentage of living species of higher Mammalia indicates that the geological clock had struck the hour when he may be looked for.

THE APPEARANCE OF THE RIVER-DRIFT HUNTER AT CRAYFORD AND ERITH.

The living species in the forest bed are to be looked upon as an advanced guard of a great migration of Asiatic and African species, finding their way into North-western Europe, over the plains of Russia, and over barriers of land connecting Northern Africa with Spain by way of Gibraltar, and with Italy by way of Malta and Sicily (see "Cave Hunting and Early Man").

In the course of time the other living species followed, and extinct species become more rare. In the deposits, for instance, of the ancient Thames, at Illford and Grays Thurrock in Essex, and at Erith and Crayford in Kent, out of twenty-six species, six only belong to extinct forms—the new comers comprising the lion, wild cat, spotted hyena, and otter, the bison and the musk

sheep. A flint flake discovered by the Rev. Osmund Fisher, at Crayford, and a second discovered by Messrs. Cheadle and Woodward, at Erith, prove that man was present in the valley of the Thames at this time; while the more recent discoveries of Mr. Flaxman Spurrell indicate the very spots where the palæolithic hunter made his implements, and prove that he used implements of the River-drift type, so widely distributed over the surface of the earth. The arctic animals at this time were present, but not in full force, in Southern Britain, and the innumerable reindeer which characterise the later deposits of the Pleistocene age had not, so far as we know, taken possession of the valley of the Thames.

To what stage in the Pleistocene period are we to refer these traces of the River-drift hunter? The only answer which I am able to give is that the associated animals are intermediate between the Forest-bed group and that which characterises the late Pleistocene division in the region extending from the Alps and the Pyrenees as far north as Yorkshire. Nor am I able to form an opinion about their relation to the submergence of Middle or Northern Britain under the waves of the glacial sea. They are quite as likely to be pre- as post- glacial.

THE RELATIONS OF THE RIVER-DRIFT HUNTER OF THE LATE PLEISTOCENE TO THE GLACIAL SUBMERGENCE.

The rudely chipped implements of the River-drift hunter lie scattered through the late Pleistocene river deposits in Southern and Eastern England in enormous abundance, and as a rule in association with the remains of animals of arctic and of warm habit, as well as some or other of the extinct species of reindeer and hippopotamus, along with mammoth and wooly rhinoceros. What is their relation to the submergence of the land and the lowness of the temperature, which combined together have resulted in the local phenomena known as glacial and interglacial?

The geographical change in Northern Europe at the close of the Forest-bed age was very great. The forest of the North Sea sank beneath the waves, and Britain was depressed to a depth of no less than 2,300 feet in the Welsh mountains, and was reduced to an archipelago of islands, composed of what are now the higher lands. The area of the English Channel also was depressed, and the "silver streak" was somewhat wider than it is now, as is

proved by the raised beach at Brighton, at Bracklesham, and elsewhere, which marks the sea line of the largest island of the archipelago, the southern island as it may be termed, the northern shores of which extended along a line passing from Bristol to London. The northern shore of the Continent at this time extended eastward from Abbeville north of the Erzgebirge, through Saxony and Poland, into the middle of Russia, Scandinavia being an island from which the glaciers descended into the sea.

This geographical change was accompanied by a corresponding change in climate. Glaciers descended from the higher mountains to the sea level, and icebergs, melting as they passed southwards, deposited their burdens of clay, sand, and erratics, which occupy such a wide area in the portion then submerged of Britain and the Continent.

This depression was followed by a re-elevation, by which the British Isles, again formed a part of the Continent, and all the large tract of country within the 100-fathom line again became the feeding-grounds of the Pleistocene Mammalia.

An appeal to the animals associated with the River-drift implements will not help us to fix the exact relation of man to these changes, because they were in Britain before as well as after the submergence and were living throughout in those parts of Europe which were not submerged. It can only be done in areas where the submergence is clearly defined. At Salisbury, for instance, the River-drift hunter may have lived either before, during or after the southern counties became an island. When, however, he hunted the woolly and leptorhine rhinoceros, the mammoth, and the horse in the neighborhood of Brighton, he looked down upon a broad expanse of sea, in the spring flecked with small icebergs, such as those which dropped their burdens in Bracklesham Bay. At Abbeville, too, he hunted the mammoth, reindeer, and horse down to the mouth of the Somme on the shore of the glacial sea.

The evidence is equally clear that the River-drift hunter followed the chase in Britain after it had emerged from beneath the waters of the glacial sea, from the fact that the river deposits in which his implements occur either rest upon the glacial clays, or are composed of fragments derived from them, as in the oft-quoted cases of Hoxne and Bedford. Further, it is very probable that he may have wandered close up to the edge of the glaciers then covering the higher hills of Wales and the Pennine chain.

The severity of the climate in winter at this time in Britain is proved, not merely by the presence of the arctic animals, but by the numerous ice-born blocks in the river gravels dropped in the spring after the break-up of the frosts.

THE RANGE OF THE RIVER-DRIFT MAN ON THE CONTINENT AND IN THE MEDITERRANEAN AREA.

The River-drift man is proved, by the implements which he left behind, to have wandered over the whole of France, and to have hunted the same animals in the valleys of the Loire and the Garonne as in the valley of the Thames. In the Iberian peninsula he was a contemporary of the African elephant, the mammoth, and the straight-tusked elephant, and he occupied the neighborhood of both Madrid and Lisbon. He also ranged over Italy, leaving traces of his presence in the Abruzzo, and in Greece he was a contemporary of the extinct pigmy hippopotamus (*H. Pentlandi*). South of the Mediterranean his implements have been met with in Oran, and near Kolea in Algeria, and in Egypt in several localities. At Luxor they have been discovered by General Pitt-Rivers in the breccia, out of which are hewn the tombs of the kings. In Palestine they have been obtained by the Abbé Richard between Mount Tabor and the sea of Tiberias, and by Mr. Stopes between Jerusalem and Bethlehem. Throughout this wide area the implements, for the most part of flint or of quartzite, are of the same rude types, and there is no difference to be noted between the *haches* found in the cave of Cresswell in Derbyshire, and those of Thebes, or between those of the valley of the Somme and those of Palestine. Nor is our survey yet ended.

THE RIVER-DRIFT MAN IN INDIA.

The researches of Foote, King, Medlicott, Hacket, and Ball, establish the fact that the River-drift hunter ranged over the Indian peninsula from Madras as far north as the ualley of the Nerbudda. Here we find him forming part of a fauna in which there are species now living in India, such as the Indian rhinoceros and the arnee, and extinct types of oxen and elephants. There were two extinct hippopotami in the rivers, and living gavials, turtles, and tortoises. It is plain, therefore, that at this time the fauna of India stood in the same relation to the present fauna as the European fauna of the late Pleistocene does to that now living in Europe. In both there was a similar association

of extinct and living forms, from both the genus *Hippopotamus* has disappeared in the lapse of time, and in both man forms the central figure.

THE RIVER-DRIFT HUNTER IN NORTH AMERICA.

We are led from the banks of tropical India to the banks of the Delaware in New Jersey by the recent discoveries of Dr. C. C. Abbott in the neighborhood of Trenton. After a study of his collection in the Peabody Museum in Cambridge, Mass., I have had the opportunity of examining all the specimens found up to that time, and of visiting the locality in company with Dr. Abbott and Professors Haynes and Lewis. The implements are of the same type as those of the river gravels of Europe, and occur under exactly the same conditions as those of France and Britain. They are found in a plateau of river gravel forming a terrace overlooking the river, and composed of materials washed down from the old terminal moraine which strikes across the State of New Jersey to the westward. The large blocks of stone and the general character of the gravel point out that during the time of its accumulation there were ice-rafts floating down the Delaware in the spring, as in the Thames, the Seine, and the Somme. According to Professor Lewis it was formed during the time when the glacier of the Deleware was retreating ("late glacial"), or at a later period ("post-glacial"). The physical evidence is clear that it belongs to the same age as deposits with similar remains in Britain. The animal remains also point to the same conclusion. A tusk of mastodon is in Dr. Cooke's collection at Brunswick, New Jersey, obtained from the gravel, and Dr. Abbott records the tooth of a reindeer and the bones of a bison from Trenton. Here, too, living and extinct species are found side by side.

Thus in our survey of the group of animals surrounding man when he first appeared in Europe, India, and North America, we see that in all three regions, so widely removed from each other, the animal life was in the same stage of evolution, and "the old order" was yielding "place unto the new." The River-drift man is proved by his surroundings to belong to the Pleistocene age in all three.

The evidence of Palæolithic man in South Africa seems to me unsatisfactory, because as yet the age of the deposits in which the implements are found has not been decided.

GENERAL CONCLUSIONS.

It remains now for us to sum up the results of this inquiry, in which we have been led very far afield. The identity of the implements of the River-drift hunter proves that he was in the same rude state of civilisation, if it can be called civilisation, in the Old and New Worlds, when the hands of the geological clock pointed to the same hour. It is not a little strange that his mode of life should have been the same in the forests to the north as south of the Mediterranean, in Palestine, in the tropical forests of India, and on the western shores of the Atlantic. The hunter of the reindeer in the valley of the Deleware was to all intents and purposes the same sort of savage as the hunter of the reindeer on the banks of the Wiley or of the Solent. It does not, however, follow that this identity of implements implies that the same race of men were spread over this vast tract. It points rather to a primeval condition of savagery from which mankind has emerged in the long ages which separate it from our own time.

It may further be inferred, from his wide-spread range that the River-drift man (assuming that mankind sprang from one centre) must have inhabited the earth for a long time, and that his dispersal took place before the glacial submergence and the lowering of the temperature in Northern Europe, Asia, and America. It is not reasonable to suppose that the Straits of Behring would have offered a free passage, either to the River-drift man from Asia to America, or to American animals from America to Europe, or *vice versâ*, while there was a vast barrier of ice or of sea, or of both, in the high northern latitudes.

I therefore feel inclined to view the River-drift hunter as having invaded Europe in pre-glacial times along with the other living species which then appeared. The evidence, as I have already pointed out, is conclusive that he was also glacial and post-glacial.

In all probability the birth-place of man was in a warm if not a tropical region of Asia, in "a garden of Eden," and from this the River-drift man found his way into these regions where his implements occur. In India he was a member of a tropical fauna, and his distribution in Europe and along the shores of the Mediterranean prove him to have belonged either to the temperate or the southern fauna in those regions.

It will naturally be asked, to what race can the River-drift man be referred? The question, in my opinion, cannot be answered in the present stage of the inquiry, because the few fragments of human bones discovered along with the implements are too imperfect to afford a clue. Nor can we measure the interval in terms of years which separates the River-drift man from the present day, either by assuming that the glacial period was due to astronomical causes, and then proceeding to calculate the time necessary for them to produce their result, or by an appeal to the erosion of valleys or the retrocession of waterfalls. The interval must, however, have been very great to allow of the changes in geography and climate, and the distribution of animals which has taken place—the succession of races, and the development of civilisation before history began. Standing before the rock-hewn tombs of the kings of Luxor, we may realise the impossibility of fixing the time when the River-drift hunter lived on the site of ancient Thebes, or of measuring the lapse of time between his days and the splendor of the civilisation of Egypt.

In this inquiry, which is all too long, I fear, for my audience and all too short, I know, for my subject, I have purposely omitted all reference to the successor of the River-drift man in Europe—the Cave man, who was in a higher stage of the hunter civilisation. In the course of my remarks you will have seen that the story told by the rudely chipped implements found at our very doors in this place, forms a part of the wider story of the first appearance of man, and of his distribution on the earth—a story which is to my mind not unfitting as an introduction to the work of the Anthropological Section of this meeting of the British Association.

THE SUCCESSIVE PALÆOZOIC FLORAS OF CANADA.

By J. W. Dawson, LLD., F.R.S.

Read before the American Association for the Advancement of Science at its Montreal meeting, August 1882.

In eastern Canada, and more especially in the Maritime Provinces, we are so fortunate as to possess very complete and well developed representatives of the Carboniferous and Erian or Devonian systems, and more especially of their shallow-water and estuarine formations. We thus have a nearly continuous series of fossil plants extending all the way from the Silurian to the Permian, and embracing seven sub-floras, as they may be termed, all more or less distinguishable from each other.

In a report recently prepared by request of the Director of the Geological Survey of Canada, and soon to be published, I have endeavored to characterize these several sub-floras so as to render them useful to practical geologists; and in the present paper I propose to illustrate them in such a manner as to direct the attention of members of the Geological section of the Association to the succession observed, and to the use which may be made of it, whether for theoretical or practical purposes.

I shall begin, for convenience, with the newer, and proceed to the older formations.

1. CARBONIFEROUS FLORA.

(1.) *Permo-Carboniferous Sub-flora* :—

This occurs in the upper member of the carboniferous system of Nova Scotia and Prince Edward Island, originally named by the writer the Newer Coal Formation, and more recently the Permo-Carboniferous; and the Upper beds of which may not improbably be contemporaneous with the Lower Permian or Lower Dyas of Europe. In this formation there is a predominance of red sandstones and shales, and it contains no productive beds of coal. Its fossil plants are for the most part of species found in the Middle or Productive Coal-formation, but are less numerous, and there are a few new forms akin to those of the European Permian. The most characteristic species of the

upper portion of the formation, which has the most decidedly Permian aspect, are the following:—

Dadoxylon materiarium, Dawson.
* *Walchia* (*Araucarites*) *robusta*, *Dn.*
* *W.* (*A.*) *gracilis*, Dn.
Calamites Suckovii, Brongt.
C. Cistii, Brongt.
* *C. Gigas*, Brongt.
Neuropteris rarinervis, Bunbury.
Alethopteris nervosa, Brongt.
Pecopteris arborescens, Brongt.
* *P. rigida*, Dn.
P. oreopteroides, Brongt.
* *Cordaites simplex*, Dn.

Of these species those marked with an asterisk have not yet been found in the Middle or Lower members of the Carboniferous system. They will be found described and several of them figured in my Report on the Geology of Prince Edward Island. The others are common and widely diffused Carboniferous species, some of which have extended to the Permian period in Europe as well. From the Upper beds characterized by these and a few other species, there is a gradual passage downward into the productive-Coal measures, and a gradually increasing number of true Coal-formation species.

It is worthy of remark here that the association in the Permo-Carboniferous of numerous trunks of *Dadoxylon* with leafy branches of *Walchia* and with fruits of the character of *Trigonocarpa*, seems to show that these were parts of one and the same plant.

(2.) *Coal-Formation Sub-flora* :—

The Middle or Productive Coal-formation, containing all the beds of coal which are mined in Nova Scotia and Cape Breton, is the head-quarters of the Carboniferous flora. From this formation I have catalogued* 135 species of plants; but as several of these are founded on imperfect specimens, the number of actual species may be estimated at 120. Of these more than one half are species common to Europe and America. No less than nineteen species are *Sigillariæ*, and about the same number are

* Acadian Geology, and Report on Flora of Lower Carboniferous 1873

Lepidodendra. About fifty are Ferns and thirteen are *Calamites, Asterophyllites* and *Sphenophylla.* The great abundance and number of species of *Sigillariæ, Lepidodendra* and ferns are characteristic of this sub-flora; and among the ferns certain species of *Neuropteris, Pecopteris, Alethopteris* and *Sphenopteris,* greatly preponderate.

(3.) *The Millstone Grit Sub-flora:—*

In this formation the abundance of plants and the number of species are greatly diminished. Trunks of Coniferous trees of the species *Dadoxylon Acadianum,* having wide wood-cells with three or more series of discs and complex medullary rays, become characteristic. *Calamites undulatum* is abundant and seems to replace *C. Suckovii,* though *C. cannæformis* and *C. Cistii* continue. *Sigillariæ* become very rare, and the species of *Lepidodendron* are few, and mostly those with large leaf-bases. *Lepidofloyos* still continues and *Cordaites* abounds in some beds. The ferns are greatly reduced, though a few characteristic Coal-formation species occur, and the genus *Cardiopteris* appears. Beds of coal are rare in this formation; but where they occur there is in connection with them a remarkable anticipation of the Coal-formation flora, which would thus seem to have existed locally in the Millstone Grit period, but to have found itself limited by generally unfavorable conditions. In America, as in Europe, it is in the North that this earlier development of the Coal Flora occurs, while in the South there is a lingering of the older forms in the newer beds.

(4.) *The Lower Carboniferous Sub-flora:—*

This group of plants is best seen in the Shales of the Horton series, under the Lower Carboniferous marine limestones. It is small and peculiar. The most characteristic species are the following:—

Dadoxylon (Palæoxylon), antiquius, Dn.—A species with large medullary rays of three or more series of cells.

Lepidodendron corrugatum, Dn.—A species closely allied to *L. Veltheimianum* of Europe, and which is its American representative. This is perhaps the most characteristic plant of the formation, and presents very protean appearances, in its old stems, branches, twigs and *Knorria* forms. It had well characterized stigmaria roots, and constitutes the oldest erect forest known in Nova Scotia.

Lepidodendron tetragonum, Sternberg.

L. obovatum, Sternb.

L. aculeatum, Sternb.

L. dichotomum, Sternb.

These species are comparatively rare, and the specimens are too imperfect to render their identification certain.

Cyclopteris (*Aneimites*) *Acadica*, Dn.—A very characteristic fern, allied in the form of its fronds to *C. tenuifolia* of Goeppert, to *C. nana*, of Eichwald, and to *Adiantites antiquus* of Stur. Its fructification, however, is nearer that of *Aneimia* than to that of *Adiantum*.

Ferns of the genera *Cardiopteris* and *Hymenophyllites* also occur, though rarely.

Ptilophyton plumula, Dn.—This is the latest appearance of this Erian genus, which also occurs in the Lower Carboniferous of Europe and of the United States.

Cordaites borassifolia, Brongt.

On the whole, this small flora is markedly distinct from that of the Millstone Grit and true Coal formation, from which it is separated by the great length of time required for the deposition of the marine limestones and their associated beds, in which no land plants have been found; nor is this gap filled up by the conglomerates and coarse arenaceous beds which, as I have explained in Acadian Geology, in some localities, take the place of the limestones.

In my Report on the Plants of the Millstone Grit and Lower Carboniferous, I have referred at length to their relation to the foreign beds of similar age, and which are known to geologists by a number of local names.

2. ERIAN FLORA.

(1.) *Upper Erian Sub-flora* :—

This corresponds to the Catskill and Chemung of the New York series, and to the Upper Devonian of Europe.

The flora of this formation, which consists mostly of sandstones, is not rich. Its most distinctive species on both sides of the Atlantic seem to be the ferns of the genus *Archaeopteris*, along with species referred to the genus *Cyclopteris*, but which,

in so far as their barren fronds are concerned, for the most part resemble *Archaeopteris*.

The representative species *Archaeopteris Jacksoni*, *A. Rogersi* and *A. Gaspiensis*, are described in the Report above referred to, as well as *Cyclopteris obtusa* and *C. Brownii*, both very characteristic species.

Leptophleum rhombicum and fragments of *Psilophyton* are also found in the Upper Erian. There is evidence of the existence of extensive forests probably of Lycopodiaceous trees in this period, in the deposits of spore-cases (*Sporangites Huronensis*) in the shales of Kettle Point, Lake Huron; and Prof. Orton, of Columbus, Ohio, informs me that extensive deposits of similar character exist in that State, though with accompaniments which suggest doubt as to the origin above stated.

The Upper Erian Flora is thus very distinct from that of the Lower Carboniferous, and the unconformable relation of the beds may perhaps indicate a considerable lapse of time. Still, even in countries where there appears to be a transition from the Carboniferous into the Devonian, the characteristic flora of each formation may be distinguished.

(2.) *Middle Erian Sub-flora.*

Both in Canada and the United States that part of the great Erian System which may be regarded as its middle division, the Hamilton and Marcellus Shales of New York, the Cordaites Shales of St. John, New Brunswick, and the Middle Shales and Sandstones of the Gaspé series, presents conditions more favorable to the abundant growth of land plants than either the Upper or Lower member. In the St. John beds in particular, there is a rich fern flora, comparable with that of the Coal formation. It is, however, distinguished by a prevalence of small and delicate species, and by such forms as *Hymenophyllites* and the smaller Sphenopterids, and also by some peculiar ferns, as *Archaeopteris* and *Megalopteris*. In addition to ferns, it has small *Lepidodendra*, of which *L. Gaspianum* is the chief. *Calamites* occur, *C. radiatus* being the dominant species. This plant, which in Europe, appears to reach up into the Lower Carboniferous, is so far strictly Erian in America. *Sigillariæ* scarcely appear, but *Cordaites* is abundant, and the earliest known species of *Dadoxylon* appear, while the *Psilophyton* so characteristic of the Lower Erian, still continues, and the remarkable aquatic

plants of the genus *Ptilophyton* are locally abundant. A tabular view of this flora will be found in Part I. of my Report.

(3.) *Lower Erian Sub-flora.*

This belongs to the Lower Devonian Sandstones and Shales, and is best seen in that formation at Gaspé and the Bay des Chaleurs. It is characterised by the absence of true ferns, *Calamites* and *Sigillariæ*, and by the presence of such forms as *Psilophyton*, *Arthrostigma*, *Leptophleum* and *Prototaxites*. *Lepidodendron Gaspianum* and *Leptophleum* already occur, though not nearly so abundant as *Psilophyton*.

The Lower Erian plants have an antique and generalised aspect which would lead us to infer that they are near the beginning of the land flora, and practically few indications of land plants have been found earlier within the limits of Canada.

(3.) THE SILURIAN FLORA AND STILL EARLIER INDICATIONS OF PLANTS.

In the Upper beds of the Silurian, those of the Helderberg series, we still find *Psilophyton* and *Prototaxites*; but below these we have no land plants. In the United States, Lesquereux and Claypole have described remains which may indicate the existence of Lycopodiaceous and Annularian types as far back as the beginning of the Upper Silurian, and Hicks has found *Prototaxites* and *Psilophyton* in beds as old in Wales, along with some uncertain stems named *Berwynia*. In the Lower Silurian the *Protannularia* of the Skiddaw series in England, may represent a land plant, but this is uncertain, and no similar species has been found in Canada.

Specimens of the so-called *Eopteris* found in rocks equivalent to the Hudson river series in France, convince me that this is nothing but an aggregation of tabular crystals of pyrite, which would seem, however, to have formed around thread-like stems perhaps belonging to Algae, or perhaps of the nature of scolithoid burrows.

The Cambrian rocks are so far barren of land plants; the so-called *Eophyton* being evidently nothing but markings, probably produced by crustaceans and other aquatic animals. In the still older Laurentian, the abundant beds of graphite probably indicate the existence of plants, but whether aquatic or terrestrial it is impossible to decide at present. I have discussed this subject

in a paper on the Laurentian Graphite in the Journal of the Geological Society of London (1870).

It would thus appear that in so far as Canada is concerned, our certain knowledge of Land Vegetation begins with the Upper Silurian, and that its earliest forms were Acrogens allied to Lycopods and prototypal gymnosperms, forerunners of the conifers. In the Lower Devonian little advance is made. In the Middle Devonian this meagre flora had been replaced by one rivalling that of the Carboniferous, and including Pines, Tree-ferns, and arboreal forms of Lycopods and of Equisetaceous plants, as well as numerous herbaceous plants. At the close of the Erian the flora again became meagre, and continued so in the Lower Carboniferous. It again became rich and varied in the Middle Carboniferous, to decay in the succeeding Permian.

In the Mesozoic a new flora appears; and in Western Canada we have, in the Middle Cretaceous, forests of Angiospermous Exogens comparable with those of modern times and including many modern genera. In Eastern Canada we have no known representative of the floras which intervened between the Permian and Pleistocene.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The thirty-first meeting of this Association was held at Montreal under the presidency of Principal J. W. Dawson, of McGill College, from August 23rd to 30th inclusive. The meeting was called to order at 10 A.M. on the 23rd, by the retiring president, Prof. Geo. J. Brush, who called upon the president elect to occupy the chair.

Addresses of welcome were delivered by the Mayor of the city on behalf of the citizens, and by Dr. Sterry Hunt, Chairman ot the Local Committee. The President replied to these addresses. The work of organising the Sections of the Association was then proceeded with, and at one o'clock the Association sat down to a sumptous lunch, tendered by the Local Committee.

On the evening of the opening day the the address of the retiring president was delivered to a large audience in the Queen's Hall, the subject being the "Progress of American Mineralogy." Following this address came a reception of the members of the Association by the Local Committee in the Assembly Rooms of the same building.

On Thursday the special work of the various Sections was opened by addresses from the several vice-presidents, and continued from day to day until all the papers accepted had been read. On Thursday, 24th inst., Principal Dawson tendered the Association a reception in the new Peter Redpath Museum, which was then formally opened. During a portion of the evening an address on Caves and Cave Scenery was given in the Lecture Theatre of the Museum, by Rev. H. C. Horey. Saturday, the 26th August, was devoted to excursions to Quebec and Ottawa, in one or other of which nearly all the members present took part. On Tuesday evening Dr. W. B. Carpenter, of London, lectured in the Queen's Hall on the "Temperatures of the Deep Sea." The Association adjourned on Wednesday, 30th August, to meet in Minneapolis, Minn., in August, 1883.

During the Session of the Association numerous receptions were tendered the members by prominent citizens of Montreal, and besides the larger excursions noted, smaller ones to the Lachine Rapids and the Victoria Bridge and Grand Trunk Railway Shops were provided for the unoccupied hours. A final excursion to Lake Memphremagog was tendered the Association on Thursday, August 31st, by the South Eastern Railway, and was enjoyed by many of the members who remained to the end.

The Montreal meeting was, with one exception, the largest which has ever been held, the total number of names registered being 937. One of the prominent features of this meeting was the presence of several distinguished European scientists, such as Dr. Samuel Haughton of Dublin, M. Rudolph Koënig of Paris, Dr. J. H. Gilbert, well known in connection with investigations in Agricultural Chemistry; Prof. J. Szabo of Buda-Pesth; Dr. John Rae, celebrated as an Arctic Explorer; Prof. D. W. Kowalevsky of Moscow; Dr. W. B. Carpenter of London. We append a list of the papers read in the Chemical, Geological and Geographical, Biological, Histological and Microscopical, and Anthropological Sections.

CHEMISTRY.

Thomas W. Tobin: On the causes which render flour and organic dust explosive, with suggestions for the prevention of such explosions.

Leonard P. Kennicutt: Action of water at 100° C. on the B-phenyltribrompropionic acid.

Albert R. Leeds: Preliminary notice of a new organic base.

H. CARRINGTON BOLTON: Application of organic acids to the examination of minerals: Note on the absorption spectrum of humic acid.

C. F. MABERY and RALPH WILSON: The action of basic hydrate on chlortribrompropionic acids: On certain substituted acrylic and propionic acids.

CHAS. W. DABNEY, Jr.: Notes on effects of different soils upon soluble phosphates; Some derivatives of isopicraminic acid; A benzoyl anhydro acid from B-metamidosalicylic.

C. F. MABERY: On the products of the distillation of wood at low temperatures.

C. C. CALDWELL: Pemberton's Method for the volumetric determination of phosphoric acid.

HARVEY W. WILEY and C. A. CROMPTON: Estimation of dextrine in solid commercial starch sugar by loss of rotatory power on solution.

ARTHUR H. ELLIOTT and FRED. SANDS: Notes on Bone Oil.

R. B. WARDER: Observations on the contamination of City Wells.

ERNEST H. COOK: Carbon dioxide in the Atmosphere; A simple laboratory appliance.

ARTHUR H. ELLIOTT: On Nitro-saccharose.

Paper from several Agricultural Chemists on the estimation of reverted phosphoric acid.

HARVEY W. WILEY: Direct estimation of dextrose, dextrine and maltose in commercial amylose (sugar starch).

J. B. LAWES and J. H. GILBERT: Determinations of nitrogen in the soils of some of the experimental fields at Rothamsted, and the bearing of the results on the question of the sources of the nitrogen of our crops.

J. SZABO: On a new micro-chemical method of determining the feldspars in rocks.

J. KITSEE: Fire-damp indicator.

C. G. WHEELER and F. MENZEL: Transmission of gases through liquids of different densities.

HENRY CARMICHAEL: The solution and late crystallization of gold heated with chlorohydric acid in a sealed tube.

WILLIAM DUDLEY: Remarks on the application of the Iridium knife-edge to analytical balances.

WM H. ELLIS: Some Tea analyses.

L. W. ANDREWS: On the constitution of Benzole.

GEOLOGY AND GEOGRAPHY.

JAMES HALL: On the relations of Dictyophyton, Phragmodictyum and similar forms with Uphantænia; Note upon the genus Plumulites.

EDWARD ORTON: A Source of the bituminous matter in the Ohio Black Shale (Huron Shale of Newberry); Suggestions as to the History of the Lower Coal-measures of Ohio.

RICHARD OWEN: Contribution to Seismology.

William Bross: The Topography and Geology of the Great Salt Lake valley.

Charles Whittlesey: Pre-glacial channel of Eagle River, Lake Superior.

J. F. Whiteaves: Recent Discoveries of Fossil Fishes in the Devonian Rocks of Canada; Note on the occurrence of Siphonotreta Scotica in the Utica formation near Ottawa, Ont.

T. Sterry Hunt: The Eozoic Rocks of Central and Southern Europe; The Serpentines of Italy.

John Rae: Arctic Explorations in North America.

Wm. B. Dwight: Recent investigations and palæontological discoveries in the Wappinger limestone of Dutchess and neighboring counties, New York.

Samuel Lockwood: A Mastodon Americanus in a Beaver dam near Freehold, N. J.

Robert B. Warder: Silicified stumps of South Park, Col.

J. W. Dawson: Palæozoic Floras of Eastern North America and more especially of Canada.

J. R. Bartlett: Deep-sea soundings and temperatures in the Gulf Stream off the Atlantic Coast, taken under the direction of the U. S. Coast Survey.

Jos. W. Spencer: Terraces and Beaches about Lake Ontario; Occurrence of Graptolites in the Niagara Formation of Canada.

Geo. H. Cook: On the Change of relative level of the ocean and uplands on the Eastern coast of North America.

M. L. Britton: On a Post-Tertiary Deposit containing impressions of leaves in Cumberland County, N. J.

W. O. Crosby: On the classification and origin of Joint Structure.

G. H. Perkins: On the Winooski Marble of Vermont, with exhibition of specimens.

Alexis A. Julien: The Comparative stratigraphy of the crystalline rocks of North Carolina and Canada: The Genesis of the crystalline iron ores of North Carolina and Northern Michigan; The Dunyte beds of North Carolina; The Felsyte-tufa of Colorado.

H. F. Walling: The origin of joint cracks.

H. Carvil Lewis: The great terminal moraine across Pennsylvania.

E. W. Claypole: Note on the exterior markings of bark of Lepidodendron Chemungense; On Amphicœlia Cedarvillensis from the Niagara group of Cedarville, Ohio; Note on the Fauna of the Catskill Red Sandstone.

Chas. A. Graham: A Rocking Stone in New York city.

W. Hamilton Merritt: Occurrence of Magnetic ore deposits in Victoria County, Ontario.

Henry S. Williams: The Undulations of the rock-masses across Central New York State.

D. W. Kowalevsky: Freshwater lignitic series of the beds in the Cretaceous formation of France.

John C. Smock: On the surface limit of the thickness of the Continental glacier in New Jersey and adjacent States, with notes on glacial phenomena in the Catskills.

C. H. Hitchcock: The Glacial flood of the Connecticut River Valley.

J. S. Nrwberry: Some mooted points in American Geology; Genesis of North American Flora.

J. Beaufort Hurlburt: Currents of air and ocean in connection with climate; Regions of summer rains and summer droughts.

Horace C. Hovey: Subterranean Map-making, with new maps of Mammoth and Luray Caves.

Richard Owen: Law of fracture or fissuring, applied to Inorganic and Organic matter.

F. Cope Whitehouse: The Caves of Staffa and their relation to the ancient civilization of Iona.

R, B. Hare: On the association of crystals of Quartz and Calcite in parallel position.

BIOLOGY.

Thomas Meehan: The Fertilization of Yucca.

William Osler: Demonstrations of a series of Brains prepared by Giacomi's method.

Robt. E. C. Stearns: Description of a new species of Alcyonoid Polyp.

W. H. Edwards: On the Polymorphism of Lycæna pseudargiolus

E. W. Claypole: Note on the Sterility of the Canada Thistle at Yellow Springs, Ohio; Insects *versus* Flowers in the matter of fertilization; Note on the occurrence of traces of a Northern Flora in Southwestern Ohio.

Wm. Saunders: On the Mouth of the larva of Chrysopa.

Mrs. A. B. Blackwell: Cross heredity from sex to sex.

Asa Gray: Some remarks on tne Flora of North America.

Henry F. Osborn: Achænodon from the Bridger Eocene beds.

Henry O. Marcy: The Placental development in Mammals.

W. S. Beal: The motion of roots and radicles of Indian Corn and beans.

C. V. Riley: Observations on the fertilization of Yucca, and on structural and anatomical peculiarities in Pronuba and Prodoxus; The Hibernation of Aletia xylina in the U. S., a settled fact; Emulsions of petroleum and their value as insecticides.

W. K. Brooks: A sketch of the History of our knowledge of the budding of Salpa; Fritz Miller and the Nauplius of Decapods.

T. Wesley Mills: Examination of some controverted points of the physiology of voice.

G. Macloskie: Achenial hairs and fibres of Compositæ; Observations on the Elm-leaf Beetle (Galeruca xanthomelana).

Wm. H. Seaman: Blastesis tridens; a pear-tree fungus.

J. F. Whiteaves: On a recent species of Heteropora from the Strait of Juan de Fuca.

W. A. Buckhout: On the Gall Mites.

J. A. Lintner: A new Sexual character in the pupæ of some Lepidoptera; On an Egg parasite of the currant saw-fly, Nematus ventricosus.

Clarence J. Blake: On the position of the Gamopetalæ; Progressive growth of Dermoid coat of the Membrana tympani.

Frank Baker: The Morphology of arteries.

Albert S. Bickmore: The Jessup collection to illustrate American Forestry in the Museum of Natural History, Central Park, New York.

Lester F. Ward: The Organic Compounds in their relations to life; Classification of organisms.

Burt G. Wilder: On the habits of Cryptobranchus.

C. E. Bessey: Some observations on the action of frost upon leaf-cells.

Edward D. Cope: The Fauna of the Puerco Eocene; The primary divisions of the Ungulata.

Wyllis A. Silliman: Remarks on the Turbellaria.

Jos. F. James: Monograph of the Clematidæ of the United States.

Sereno Watson: Notes on the Flora of the Rocky Mountains.

HISTOLOGY AND MICROSCOPY.

Wm. B. Carpenter: On angular aperture in relation to biological investigation.

W. Osler: Demonstration of the Bacillus of Tuberculosis; The third Corpuscular element in the Blood; The development of Blood Corpuscles in the bone-marrow; Note on the Microcytes of the blood, and their probable origin.

Louis Elsberg Plant-"cells" and living matter.

Henry O. Marcy: Histology of uterine fibroid tumors. Illustrated by micro-photographs.

T. J. Burrill: Some Vegetable poisons.

W. A. Rogers: A Study of the problem of fine rulings with reference to the limit of naked eye visibility of microscopic resolution; On a new form of dry mounting.

Thomas Taylor: The House Fly considered in connection with the distribution of infections and contagious poisons; A new economic freezing Microtome for section-cutting, with new mechanical devices.

A. H. Tuttle; On the epidermis of Marsipobranchs.

D. P. Penhallow: Notes on some of the pecularities incident to the diseases of fruit.

Romeyn Hitchcock: Notes on the present status of sanitary inspection, with special reference to the examination of water and air.

C. E. Hanman: A filtering wash-bottle adapted to the use of the Histologist.

J. H. Pillsbury: Development of Cilia in the planula of Clara leptostyla.

ANTHROPOLOGY.

OTIS T. MASON: A Scheme of Anthropology.

CHARLES WHITTLESEY: The Cross and the Crucifix.

G. H. PERKINS: Notice of a collection of Sioux weapons and articles of dress; Recent Archæological discoveries in Vermont.

J. McNAB CURRIER: Stone Implements from Bomoseen and Castleton Valleys.

CHARLES RAU: A Stone Grave in Illinois.

ALBERT S. GATSCHET: Chief deities in American religions.

MRS. ERMINNIE A. SMITH: Beliefs and Superstitions of Iroquois Indians; A few deductions from a dictionary of the Tuscarora dialect.

J. OWEN DORSEY: On the comparative phonology of four Siouan languages; The kinship system and marriage laws of the Dhegiha.

P. R. HOY: Who made the native copper implements? Who built the mounds?

F. W. PUTNAM: On copper implements and ornaments from North America; Discovery of a log-building belonging to the stone-grave period in Tennessee; Account of three mounds explored in Ohio and Tennessee; The contents of eighty-four stone graves at Brentwood, Tenn.

HORATIO HALE; Indian migrations, as evidenced by language.

J. W. PHENE: On some hitherto unnoted affinities between ancient customs in America and on the other continents.

R. G. HALIBURTON: Atlas and the Atlantes.

H. N. RUST: A "find" of chipped stone articles on the Pacific coast and exhibition of the specimens; Remarks upon the Davenport tablet.

WILLIS DEHASS: Monumental and art remains in the Lake regions of Ohio, Pennsylvania and New York; Mountain antiquities; Geological testimony to the antiquity of man in America; Archæological exploration, progress of discovery.

A. E. DOUGLAS: A find of ceremonial weapons in Florida.

MISS ALICE C. FLETCHER: Home Life among some of the Indian tribes; Religious ceremonials of some of the Dakotan Family of Indians.

MISS VIRGINIA K. BOWERS: The bleaching of the Aryans.

WM. H. HINGSTON: Influence of Climate of Canada on Europeans.

Published Nov. 1, 1882.

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

ON PORTIONS OF THE SKELETON OF A WHALE FROM GRAVEL ON THE LINE OF THE CANADA PACIFIC RAILWAY, NEAR SMITH'S FALLS, ONTARIO.

By J. W. Dawson, LL.D., F.R.S.

Bones of large whales are of not infrequent occurrence on the less elevated terraces of the Pleistocene period on the Lower St. Lawrence. I have seen them at several places in the neighborhood of Metis, on the lowest sea terrace, now elevated only a few feet above the level of the sea, and they are reported to have been found on the second terrace at an elevation of 60 to 70 feet. Mr. Richardson, late of the Geological Survey, informs me that he has seen them in several other places on the lower terraces. It has also been reported that bones of a whale were found on Mt. Camille in rear of Metis at a considerable elevation; but Mr. Richardson, who visited the locality, failed to verify the statement. The bones found on the lower, and therefore modern terraces are usually in a good state of preservation and have a very recent appearance. The above statements relate to remains of the larger whalebone whales.

Remains of the *Beluga* or small white whale were found by the late Dr. Zadok Thompson, author of the "Natural History of Vermont," in the marine clay in the township of Charlotte, Vermont, at an elevation of 150 feet above the sea. They were associated with shells of *Saxicava* and *Leda*. The species was supposed to be distinct from the *B. Catodon*, Gray, and was named by Thompson *B. Vermontana*. I have found detached bones of *Beluga* in the Post-pliocene clays of Rivière du Loup, and considerable portions of a skeleton were found in the

excavations for the Intercolonial Railway, on the south side of the Baie des Chaleurs, and were described by Gilpin in the Transactions of the Nova Scotia Institute of Natural Science.* Bones have also been found in the brick-clays near Montreal, and a specimen was discovered several years ago in sand holding *Saxicava*, near Cornwall, Ontario. The last-named specimen was studied by Mr. Billings, and its bones compared with those of the modern species in the McGill College Museum. On this evidence Mr. Billings concluded that it belonged to the modern species, and I believe extended this conclusion to Dr. Thompson's specimen, the distinctive characters of which, as stated by that naturalist, seem not to exceed the individual differences in modern specimens.

But though the *Beluga*, which now extends its excursions far up the St. Lawrence, and has even been captured in the vicinity of Montreal, occurs as far west as Cornwall, no remains of the larger whales have, so far as I am aware, been found so far inland until the discovery of the specimens referred to in the present note. These were found, as I am informed by Archer Baker, Esq., General Superintendent of the Canada Pacific Railway, "in a ballast pit, at Welshe's, on the line of the C. P. Railway, three miles north of Smith's Falls, and thirty-one miles north of the St. Lawrence River, in the Township of Montague, County of Lanark. They occurred in gravel at a depth of 30 feet from the surface, and about 50 feet back from the original face of the pit."

Mr. Peterson, C.E., has been kind enough to obtain for me the elevation of the place where the remains were found, as indicated by the railway levels. It is 420 feet above the level of the St. Lawrence at Hochelaga, or as nearly as possible 440 feet above sea level. It is interesting to observe that this corresponds exactly with the height of one of the sea terraces on the Montreal mountain, and is only 30 feet lower than the well-marked beach with sea shells above Côte des Néiges, on the west side of the Mountain. The highest level at which Post-pliocene marine shells are known to occur on Montreal Mountain, is near the park-keeper's house, at an elevation of about 520 feet. These marine deposits of Montreal are of the same geological period with the Cetacean remains in question, so that the animal to which these belonged may have sailed past the rocky islet which

* Vol. II., 1874.

then represented Montreal Mountain at an elevation of 400 feet above the lower levels of the city, and in a wide sea which then covered all the plain of the lower St. Lawrence.

The deposit in which the remains occurred is no doubt the equivalent of the Saxicava sand and gravel, and was probably a beach or bank near the base of the Laurentian hills, forming the west side of a bay which then occupied the Silurian country between the Laurentian hills north of the Ottawa, and those extending southward toward the Thousand Islands, and which opened into a wide extension of the Gulf of St. Lawrence, reaching to the hills of Eastern Canada and New England, and westward, perhaps, to the Niagara escarpment at the head of Lake Ontario. Such a sea might well be frequented by whales in the summer season, and individuals might occasionally be stranded on shallows or driven ashore by gales or by the pressure of floating ice.

The bones secured consist of two vertebrae and a fragment of another with a portion of a rib, and others are stated to have been found. They are in good preservation but have become white and brittle through the loss of their animal matter. On comparison with such remains of whales as exist in the Peter Redpath Museum, and with the figures and descriptions of other species, I have little doubt that they belong to the Humpback whale, *Megaptera longimana* of Gray, *Balaena boops* of Fabricius, a species still common in the Gulf of St. Lawrence, and which extends its range some distance up the River, and is more disposed than most others of the large whales to haunt inland waters, and to approach the shores. I have seen it as far up the river as the mouth of the Saguenay, and there is reason to believe that occasionally it runs up much further. It is a species well known to the Gaspé whalers and often captured by them. Of course with so little material it is not possible to be absolutely certain as to the species, but I think it may safely be referred to that above named. The larger of the two vertebrae, a lumbar one, has the centrum eleven inches in transverse diameter and is seven inches in length. The smaller, a dorsal, is ten inches in its greater diameter and four in length. Through the kindness of Mr. Baker, the specimens have been deposited in the Peter Redpath Museum of McGill University.

POLYZOA OF THE QUEEN CHARLOTTE ISLANDS. PRELIMINARY NOTICE OF NEW SPECIES.

By the Rev. THOMAS HINCKS, B.A., F.R.S.

In this paper I propose to give a diagnosis of a number of Polyzoa from the Queen Charlotte Islands, entrusted to me by Dr. G. M. Dawson, on behalf of the Geological Survey of Canada.

These forms will be more fully described and figured in a special report on the Polyzoa of these islands, which I hope to publish hereafter. As the preparation of the plates may occupy some time, it seems better to record the new species at once, and so avoid the risk of being anticipated after much labor has been expended on the work.

All critical notes on the species will be reserved for the Report.

Family *Membraniporidæ.*

MEMBBANIPORA, De Blainville.

MEMBRANIPORA NIGRANS, N. SP.

Zoœcia ovate (variable, sometimes arched above and narrowing downwards, sometimes broad-ovate, sometimes oval), irregularly disposed, margins much elevated, crenate, the whole front of the cell covered by a rather coarse stout membrane of a black color; oral valve large; on each side at the top a pointed *avicularium,* placed on the margin, depressed at the base, the beak sloping upwards, mandible directed obliquely downwards; very large *avicularia*, slightly raised in front, with a broad triangular mandible, which is bent abruptly in the middle, scattered amongst the zoœcia. *Oœcium* very shallow, just covering the extremity of the cell, smooth, with a raised rib across it a little above the oral margin.

Zoarium of a deep black color, forming a large irregularly spreading crust.

Loc. Houston-Stewart Channel, Queen Charlotte Islands (*Dr. G. M. Dawson*).

MEMBRANIPORA EXILIS, N. SP.

Zoœcia oblong, quincuncial, subtruncate above and below, set closely together, of considerable size and delicate material, margin thin, a good deal raised, the front wall wholly membranous; at the top of the cell 2 spines, and 3 or 4 on each side (or some-

times a smaller number), situated on the upper half of the cell, pointed, slender, suberect, jointed to a tubular base; a sessile *avicularium* on the margin at one side (often absent), just below the top, beak sloping upwards, scarcely bent at the extremity, mandible blunt, directed obliquely outwards. *Oœcia* (?)

Loc. Houston-Stewart Channel, Queen Charlotte Islands, enveloping *Cellaria borealis*, Busk, with a very thin crust (*Dr. G. M. Dawson*).

MEMBRANIPORA CONFERTA, N. SP.

Zoœcia oval, quincuncial, set closely together, front wall wholly membranous, margin thin, smooth; on each side about 4 sharply pointed spines, and (often) a central one below, which bend rather abruptly over the area and meet in the middle; an *avicularium* at each side on the margin, just below the upper end, slightly raised, pointed, the mandible directed upwards, a small erect spine below the *avicularia;* at the bottom of the cell a single pointed *avicularium* with triangular mandible variously turned, *Oœcium* rounded, smooth, with a variously shaped depressed area (or fossa) in front, composed of thinner material than the rest of the surface, and appearing dark-colored as compared with the surrounding dense white crust.

Loc. Houston-Stewart Channel, Queen Charlotte Islands (*Dr. G. M. Dawson*).

MEMBRANIPORA LEVATA, N. SP.

Zoœcia small, oval, distinct, quincuncial, margin very slightly raised, thin, smooth, the whole front closed in by a smooth, light-colored, and rather glossy membrane, which lies very much on a level with the edge of the cell; above each zoœcium, on a somewhat quadrate area, a small nodule, with a pointed *avicularium* on one side of it, the mandible directed transversely upwards. *Oœcium* rounded, smooth, umbonate.

Loc. Houston-Stewart Channel, Queen Charlotte Islands (*Dr. G. M. Dawson*).

MEMBRANIPORA ECHINUS, N. SP.

Zoœcia quincuncial, oval, distinct, separated by rather deep interspaces, 2 spines at the top and 7–8 slender, pointed, and rather tall spines down each side, which slant inwards but do not meet in the centre; on each side, springing from below the second spine from the top, a pedicellate *avicularium*, the upper part large and much swollen (closely resembling a "bird's

head,"), very slighty hooked at the extremity, apparently jointed to an extremely thin pedicle, mandible slender, pointed. *Oœcium* (?).

Loc. Houston-Stewart Channel, Queen Charlotte Islands (*Dr. G. M. Dawson*).

Family *Cribrilinidæ*.

CRIBRILINA, Gray.

CRIBRILINA FURCATA, N. SP.

Zoœcia ovate, quincuncial, very regularly disposed, moderately convex; surface smooth and lustrous, often of a reddish-brown color, on each side four to six shallow grooves, radiating to a median line, and a central one below, which are occupied by a row of roundish pores set very closely together, the ridges between them slightly raised, usually bearing several elliptical pores: orifice arched above, straight below, much broader than high, on each side a stout bifid spine (occasionally simple); peristome much thickened in front and rising into a central mucro. *Avicularia* none. *Oœcium* large (covering about half the cell above it), rounded, taller than broad, depressed in front, with a shallow oral arch; surface smooth, rather thickly punctured.

Loc. Off Cumshewa Harbor, Queen Charlotte Islands (*Dr. G. M. Dawson*).

CRIBRILINA HIPPOCREPIS, N. SP.

Zoœcia ovate, quincuncial; surface lustrous, flattish (sutures very shallow), traversed by radiating ridges (three to five on each side), which pass from the sides to the centre (no median keel), the grooves between them occupied by a line of rather large oblong pores; at the margin of each ridge an elliptical foramen, covered in by a delicate membrane: orifice large, well arched above, constricted a little above the lower margin, which is straight; operculum of a rich reddish brown; peristome not elevated, lower margin much thickened, usually terminating on each side in a knob; large, elongate, depressed spatulate avicularia scattered amongst the cells. *Oœcium* (?).

Surface of zoarium flat; color brown, with a tinge of red, in old states white and highly calcified.

Loc. Cumshewa Harbor and Houston-Stewart Channel, Queen Charlotte Islands, on shell (*Dr. G. M. Dawson*).

Family *Myriozoidæ* (part.), Smitt.

SCHIZOPORELLA, Hincks.

SCHIZOPORELLA CRASSILABRIS, N. SP.

Zoœcia large, elongate, ovate, quincuncial, very distinct, convex, sutures not very deep; surface dense, punctured (the punctures often obliterated by the calcification; orifice suberect suborbicular, with a broad rounded sinus occupying nearly the whole of the lower margin; peristome raised and thickened, forming a wall round the orifice, often massive in front, where it is carried out into a broad projection, which is notched or sinuated in the centre. *Avicularia* none. *Oœcium* large, rounded, broader than high, with rather large punctures.

Loc. Houston-Stewart Channel, Queen Charlotte Islands 15–20 fms. (*Dr. G. M. Dawson*).

SCHIZOPORELLA LONGIROSTRATA, N. SP.

Zoœcia ovate, disposed in lines, moderately convex, (sutures shallow); surface roughened or minutely granulated, covered with an epitheca; orifice arched above, lower margin extended into a wide rounded sinus; peristome thin, elevated at each side; on one side, generally a little below the orifice, an elongate, slender, pointed, dependent *avicularium*, the mandible (which is broad at the base and tapering above) directed obliquely downwards, usually turned slightly outwards. *Oœcium* rounded flattened in front, thickly punctured, with a shallow oral arch.

Loc. Off Cumshewa Harbor, on shell (*Dr. G. M. Dawson*).

SCHIZOPORELLA INSCULPTA, N. SP.

Zoarium foliaceous and bilaminate or incrusting. *Zoœcia* large, ovate, quincuncial, depressed separated by raised lines, sutures shallow; surface vitreous, glossy, thickly covered over its whole extent with punctures; orifice arched above, the lower margin almost entirely occupied by a wide very shallow sinus; peristome thin, moderately raised, extended in front (beyond the sinus) so as to form a small chamber, in which is a rounded orifice (? *avicularium*). *Oœcia* profusely developed, very large (covering about two-thirds of the cell above), elongate, rounded above, with a tall oral arch, thickly covered with slightly granulated ridges, which radiate from the opening to the base.

Loc. Queen Charlotte Islands, under 30 fms., attached to a stem, and on shell (*Dr. G. M. Dawson*).

SCHIZOPORELLA MACULOSA, N. SP.

Zoœcia quincuncial, rather small, moderately convex, sutures shallow; surface shining, covered with small punctures, which are closed in by a brownish membrane, and give a spotted appearance to the front wall; orifice arched above, with a shallow bluntly-pointed sinus below, not contracted at the opening; peristome slightly thickened, on one side just below the orifice (or occasionally on both sides) a small rounded *avicularium* on a prominent boss. *Oœcium* (?).

Loc. Queen Charlotte Islands, on shell (*Dr. G. M. Dawson*).

SCHIZOPORELLA TUMULOSA, N. SP.

Zoœcia quincuncial, very regularly arranged, very convex, ovate, much elevated centrally below the mouth, the wall sloping steeply down to the margin of the cell; surface dense, smooth, rather glossy, areolated round the edge, ridges radiating towards the centre; orifice orbicular, with a small central sinus, not contracted at the opening, peristome not elevated; immediately below the orifice, at one side of the sinus a rostrum, bearing on one side a pointed *avicularium*, the beak very slightly bent at the extremity, mandible directed upwards, the rostrum rising into a short mucronate point behind the *avicularium;* very commonly on the front of the cell near the bottom a much raised *avicularium* (mounted on a prominent elevation), with a pointed mandible directed straight outwards. *Oœcium* rounded, smooth, much broader than high, with a tall oral arch, filled in by a calcareous plate.

Loc. Off Cumshewa Harbor, Queen Charlotte Islands, in 20 fms., forming a brownish spreading crust (*Dr. G. M. Dawson*).

SCHIZOPORELLA DAWSONI, N. SP.

Zoœcia ovate, quincuncial, very moderately convex, separated by raised lines, highly calcified, vitreous; surface reticulato-punctate (punctures appearing as deep shafts in the vitreous crust); orifice arched above, much broader than high (narrow between the upper and inferior margins); a shallow rounded sinus in the centre of the lower margin, not contracted at the opening; peristome perfectly simple, not raised. *Avicularia* none. *Oœcium* rounded, closely united to the cell above, somewhat depressed in front, glossy, covered with rather large punctures; a prominent, thickened border round the opening.

Loc. Virago Sound, Queen Charlotte Islands (*Dr. G. M. Dawson*).

SCHIZOPORELLA FISSURELLA, N. SP.

Zoœcia small, quincuncially disposed, ovate, the lower portion flattish; oral region raised, tubular, suberect; surface smooth, porcelanous, shining, sutures extremely shallow; orifice immersed, arched above, straight below, with a narrow slit-like sinus; peristome thickened and elevated round the mouth, so as to form a kind of neck, carried out in front into a mucronate process, which is sometimes notched in the centre. *Zoœcium* rounded, smooth, with a small longitudinal fissure above the opening, a central tooth-like process just within the oral arch.

Loc. Dolomite Narrows, Queen Charlotte Islands (*Dr. G. M. Dawson*).

Family *Escharidæ* (part.), Smitt.

LEPRALIA (part.), Johnston.

LEPRALIA BILABIATA, N. SP.

Zoœcia quincuncially arranged, short, very slightly convex (the sutures little more than incised lines), rounded above, widening out at each side and narrowing off towards the base, which is subtruncate; surface dense, smooth, of a somewhat waxy appearance; orifice large, occupying nearly half of the front surface, rounded above, very slightly contracted immediately above the lower margin, which is somewhat arched; peristome not elevated; operculum smooth, of a deep black color, distinctly bilabiate. *Avicularia* none. *Oœcium* a subtriangular extension of the cell above the orifice, very little raised, a great part of its front surface occupied by a large foramen, closed in by membrano-chitinous material.

Zoarium of a very dark brown color (almost black).

Loc. Houston-Stewart Channel, Queen Charlotte Islands, on shells (*Dr. G. M. Dawson*).

When the *zoœcium* is open, the orifice is occupied in great part by the entrance to a tubular passage (through which the polypide issues), which is formed *below* by the thickened border of the operculum, and *above* by a distinct chitinous rim. These two lips are brought together so as to close the entrance when the operculum is shut.

LEPRALIA NITESCENS, N. SP.

Zoœcia quincuncial, short-ovate, very ventricose; surface dense, vitreous, highly polished and glistening, smooth, with obscure radiating ridges, punctured, sometimes areolated round the margin; orifice much higher than broad, immersed in the

older cells, arched above, slightly contracted a short way above the lower margin, which is a little curved outward; peristome not raised, the inner edge of the oral aperture finely denticulate; 3 or 4 spines above; on each side, in a line with the lower margin, a strong nodulous process; about the centre of the margin an *avicularium*, with rounded mandible placed on a swelling, which extends some way below the mouth, and facing sideways, mandible directed upwards; often on the front of the cell near the bottom (to-wards one side) a bracket-like projection, bearing a rounded *avicularium*. *Oœcium* (?).

Zoarium forming a brownish patch on shell.

Loc. Houston-Stewart Channel, Queen Charlotte Islands (*Dr. G. M. Dawson*).

LEPRALIA CLAVICULATA, N. SP.

Zoœcia ovate or lozenge-shaped (sometimes irregular in shape and size), quincuncial, depressed; surface glossy, thickly covered with minute circular punctures, which give it a pretty speckled appearance; orifice arched and expanded above, slightly narrowed below, contracted by small projection on each side a short distance above the lower margin, which curves slightly outward. *Avicularia* keyhole shaped, placed on a distinct area very much smaller than that of the cell, and commonly immediately above a zoœcium, mandible directed upward. *Oœcium* very large, elongate (much higher than broad), depressed toward the opening, rising above into a kind of knob, white, glossy, thickly punctured; the surface for some distance above the oral arch frequently traversed by longitudinal furrows.

Zoarium a large, spreading crust.

Loc. Houston-Stewart Channel, Queen Charlotte Islands (*Dr. G. M. Dawson*).

MUCRONELLA, Hincks.

MUCRONELLA PRÆLUCIDA, N. SP.

Zoœcia ovate quincuncial, slightly convex, separated by raised lines, surface thickly covered with roundish punctures, lustrous; orifice arched above, lower margin straight (no denticles); peristome raised, especially at the back or in front, where it rises in the centre into a blunt mucronate projection, which bends slightly inwards, the surface of the peristome smooth, entire, and very glossy. *Avicularia* none. *Oœcium* (?).

Loc. Houston-Stewart Channel, Queen Charlotte Islands (*Dr. G. M. Dawson*).

MUCRONELLA PRÆLONGA, N. SP.

Zoœcia very long, quincuncially arranged, wider above than at the base (elongate-ovate, sometimes appearing almost subtubular), convex, depressed below, rising towards the orifice; surface thickly covered with punctures, shining (the glistening appearance due to the presence of an epitheca); orifice suborbicular, peristome elevated round it, carried out in front into a very prominent process, often much thrown back and elongated, sometimes simply pointed, sometimes bi- or trimucronate; on the inner side of it a single, small, sharply-pointed denticle; the upper margin produced in the centre into a sharp spinous process. *Avicularia* none. *Oœcium* (?).

Zoarium forming a whitish, subcircular patch on shell.

Loc. Queen Charlotte Islands (*Dr G. M. Dawson*).

SMITTIA, Hincks.

SMITTIA SPATHULIFERA, N. SP.

Zoœcia large, ovate, quincuncial, moderately convex, separated by raised lines, surface reticulato-punctate; orifice arched above, lower margin straight and within it a large bifid tooth; peristome raised and thickened, and produced below into a spout-like sinus, within which is a short spatulate *avicularium*, mandible directed downwards. *Oœcium* large, immersed, closely united to the cell above; surface roughened, punctured round the edge.

Zoarium a brownish crust on shell.

Loc. Houston-Stewart Channel, Queen Charlotte Islands (*Dr. G. M. Dawson*).

[ADDITIONAL.]

MEMBRANIPORA, De Blainville.

MEMBRANIPORA PROTECTA, N. SP.

Zoœcia contracted above, expanded below, disposed rather irregularly in lines, set closely together, front wall wholly membranous, margin smooth; 2 erect spines (sometimes bifid) at the top, below them on each side a single bifid spine, and below these 2 large, branched, antler-like spines, which meet over the aperture; numerous *avicularia* interspersed amongst the cells, placed on a distinct area; beak elongate, slanting upwards, mandible with a triangular base, the upper portion long, slender, setiform. *Oœcium* (?).

Loc. Virago Sound, Queen Charlotte Islands (*Dr. G. M. Dawson*).

Ann. & Mag. N. Hist. Ser. 5. Vol. x.

NOTE ON THE OCCURRENCE OF SIPHONOTRETA SCOTICA, DAVIDSON, IN THE UTICA FORMATION, NEAR OTTAWA, ONTARIO.

By J. F. Whiteaves, F.G.S.

(Read before American Association for Advancement of Science, Montreal, 1882)

In the spring of 1881, three specimens of a remarkable *spinose brachiopod* were collected by Mr. J. W. H. Watts, R.C.A., from a band of impure limestone in the Utica slate, at Cumming's Bridge, near Ottawa. These specimens, which Mr. Watts has since presented to the Museum of the Geological Survey of Canada, consist of two perfect examples of the beaked and perforated valve, which is probably the ventral, and of one detached dorsal valve in which the beak is obsolete. Over most of the central area of the sides of the valves the spines are broken off, and where this is the case the surface is marked with pitted imbricating concentric lamellæ—the pits representing the fractured bases of the spines. In each case the margins of the valves are densely fringed with a single and continuous row of fine hair-like spines, except immediately upon the beaks.

Upon examination with an ordinary simple lens it was at once apparent that these specimens are referable to De Vernueil's genus *Siphonotreta*, and that in most respects they bear a very close resemblance to an English species, the *S. Anglica* of Prof. Morris. But the spines of *S. Anglica* are distinctly stated to be annulated, whereas those of the Canadian specimens appeared perfectly smooth when viewed under an achromatic microscope with an inch and a half objective.

A few month ago the writer had occasion to send come Canadian fossil *Brachiopoda* to Mr. Thomas Davidson, F.R.S., for examination and comparison with British species. In the parcel forwarded the three examples of the *Siphonotreta* from Cumming's Bridge were included, and in a letter received from Mr. Davidson in May last, they are reported upon as follows:—

"The *Siphonotreta* from near Ottawa interests me much. It is identical in shape and characters with the Upper Llandeilo species, which I named *Siphonotreta Scotica*. I am very uncertain whether the Wenlock Shale species, named *S. Anglica*, by Morris, is the same or not. Only one crushed specimen of the *S. Anglica* has been found, and its spines are annulated, as described by Morris. I could see no annulations in the spines of the many specimens of *S. Scotica*, found by Mrs. Gray in the

Upper Llandeilo of Craighead, nor do I see any in your specimens. As there is uncertainty as to the specific identity of the highest Upper Silurian form with the Lower Silurian one, and as none have been found in all that mass of intervening strata, I prefer provisionally to retain the two names, or until other Upper Silurian species shall have been found."

S. Scotia was originally described and figured in the Geological Magazine for January, 1877, and if the Canadian specimens are specifically identical with those from Scotland, the species must have had a considerable range in time, for the Upper Llandeilo rocks are generally regarded as of about the same age as the Chazy Limestone of the State of New York, and the Utica Slate as corresponding to beds on a comparatively high horizon in the Caradoc or Bala Group. To the palæontologist Mr. Watt's discovery will be of special interest, as this is the first time that the occurrence of a species of *Siphonotreta* in North America has been placed upon record.

ON A RECENT SPECIES OF HETEROPORA FROM THE STRAIT OF JUAN DE FUCA.

By J. F. Whiteaves, F.G.S.

(Read before American Association for Advancement of Science, Montreal, 1882)

The genus *Heteropora* was constituted by De Blainville in 1830, for the reception of a number of fossil species of Polyzoa of the order Cyclostomata, whose characters are thus defined by Busk :—"Polyzoarium erect, cylindrical, undivided or branched; surface even furnished with openings of two kinds; the larger representing the *orifices* of the cells, and the smaller the *ostioles* of the interstitial canals or tubes." "The essential character of the genus," writes Dr. H. A. Nicholson, "is thus the possession of a skeleton made up of two kinds of tubes, larger and smaller, the latter being the most numerous." Further, it has been ascertained that the tubes of *Heteropora* are provided with cross partitions and radiating spines, and that their walls are perforated by numerous openings. These structures have been held to be the homologues of the tabulæ and septa of the tabulate corals, and of the mural pores of the Favositidæ. Lindström, in 1876, maintained that the Palæozoic fossils known to geologists as *Chætetes*, *Stenopora* and *Monticulipora* have almost exactly the

same kind of internal structure as *Heteropora*, and consequently that the former genera should be removed from the class Anthozoa, to which the true corals are supposed to belong, and placed with the Polyzoa—a conclusion which had been arrived at ten years before by Dr. Rominger.

Many species of *Heteropora* have been described from the Mesozoic and Tertiary rocks of Europe and the United States, but no living representative of the genus had been discovered until 1879. In that year Mr. Waters described and figured a recent species from Japan, under the name *H. pelliculata*, in the *Journal of the Royal Microscopical Society;* and a little later in the same year, in the *Journal of the Linnæan Society*, Mr. Busk published a diagnosis, accompanied by illustrations, of a living Polyzoon from New Zealand, which he called *H. Neozelanica.* Mr. Waters and Dr. H. A. Nicholson, however, have both expressed the opinion that the *H. Neozelanica* of Busk is identical with the previously described *H. pelliculata.*

On the coast west of Sooke, Vancouver Island, in the Strait of Juan de Fuca, Mr. James Richardson, late of the Geological Survey of Canada, found a single specimen of a recent polyzoon in 1874, which, in the writer's judgment, cannot be distinguished by any tangible character from the Japanese and New Zealand species of *Heteropora* described by Messrs. Waters and Busk. No thin sections of this specimens have been made to show the minute structures of the interior, but the whole of the outer surface has been carefully examined under the microscope, and camera drawings of some of the most striking appearances thus presented have been made. The punctured, calcareous pellicle which Mr. Waters represented as closing the mouths of the interstitial canals in *H. pelliculata*, the character which suggested that specific name, can be well seen in part of the Canadian specimen. The general shape of the Polyzoary of the latter and the microscopical character of other portions of the surface agree perfectly with Busk's figures of the corresponding parts of *H. Neozelanica.* In one portion of the surface of the Fuca polyzoon it was noticed that the apertures of some of the larger tubes project distinctly beyond the general level, a feature not specially indicated in any of Messrs. Waters' or Busk's illustrations, but this slight variation from their types can scarcely be held as indicative of a specific difference from them.

ON CANADIAN FRESH-WATER POLYZOA.*

By William Osler, M.D.

The Polyzoa, or Bryozoa as they are sometimes called, form an exceedingly interesting group of animals. From their extensive distribution in geological formations and from the abundance and great beauty of the marine species at the present day, they have attracted an unusual share of attention from naturalists, while the elegance and plant-like appearance of many of the forms make them at the sea shore and in the museum favorites with the public. For a long time the Polyzoa were classified with the hydroid polyps among the Radiata, and even by Owen, in 1855, this method was adopted. Dr. J. V. Thompson, in 1830, was the first to separate them and apply the name Polyzoa to the whole class. At present they are classified as the lowest division of the Mollusca, forming together with the Tunicates and Brachiopods the class Heterobranchiata in the old system, or the division Molluscoida in the new. The Polyzoa are divided into two orders, 1st, the Phylactolæmata, in which the tentacles are arranged in the form of a horse shoe or crescent, and which are provided with a valve guarding the throat. 2nd, the Gymnolœmata, in which the tentacles are arranged in a circle, and the throat is not provided with a valve. In the Phylactolæmata there are three sub-borders, of which the first, Lophopea, contains almost all the fresh-water species. Prof. Allman divides the Lophopea into two great families, the Cristatellidæ and the Plumatellidæ—in the former the animal is locomotive, in the latter fixed. The genera in which Canadian species occur, as far as we know at present, are Cristatella, Plumatella and Pectinatella, and the five species which I have identified *Cr. ophidioidea*, *Pl. diffusa*, *arethusa* and *vitrea*, and *Pect. magnifica*.

As I have nothing new upon this subject to bring forward, I shall proceed to make some general remarks upon the structure and life history of these creatures, and demonstrate the specimens on the table before you. I may as well here explain one or two terms which will be frequently used in the descriptions. The term *cœnœcium* when employed indicates the common system and solid basis of the animal. The external coating is

* Read before the Natural History Society.

called the ectocyst, the internal the endocyst, and the horse shoe shaped disk supporting the tentacles the *lophophore*—strictly the bearer of the plume. The first species to which I will direct your attention is the *Pectinatella magnifica* of Leidy, described by him in the proceedings of the Academy of Science of Philadelphia, for Nov., 1851, and defined as follows;—*Cœnœcium* massive, gelatinoid, hyaline, fixed, investing bodies. Orifices arranged in irregular lobate areolæ upon the free surface. Lophophore crescentic. Ova lenticular, with an annulus and marginal spines. The specimens on the table show well the hyaline gelatinous nature of the *cœnœcium* and the arrangement of the Polyps upon the surface. This is perhaps the most abundant fresh-water Polyzoon in the country, being found in the quiet waters about the mouths of the numerous streams, and in the small lakes. It is not very abundant in Quebec, but it has been found near St. Andrews, and I obtained a beautiful specimen from Lake Memphremagog. I have not seen it in the neighborhood of Montreal. This species prefers quiet, still waters, not too much exposed, nor of large extent and subject to commotion from waves. Thus I have never found it in Lake Ontario itself, but always in little sheltered marshy bays, where it is found encrusting logs, upright sticks, and the stems of rushes. My attention was early directed to this form as it exists in extraordinary profusion in the Desjardin canal, which leads from Burlington Bay to my native town Dundas. The wooden sides of the canal basin in the months of July and August are almost uniformly covered with this magnificent species. The growth begins about 1½ to 2 feet below the surface and extends in depth for the same distance or even further, rarely, however, deeper than six feet. The masses form extensive sheets usually a few inches in thickness, or else beautiful symmetrical projections, 6-12 inches in thickness, which spring either from a bed of the Polyps or are isolated. In the summer of 1867, during a visit of my friend, the Rev. W. A. Johnson, of Weston, I showed him the masses, and we agreed to subject them to examination with the microscope, not having any idea as to their real nature. Judge of our delight when we found the whole surface of the jelly was composed of a collection of tiny animals of surpassing beauty, each of which thrust out to our view in the zoophyte trough a crescent-shaped crown of tentacles. Recognizing it as a Polyp we were greatly exercised as to its position, presenting as it did

in the method of growth, such variation from the ordinary species described in our zoological text books. Happily in the American Naturalist for that year we met with Mr. Alpheus Hyatt's papers on the Fresh-water Polyzoa, then in course of publication, and obtained full information therefrom. On examining the surface of a mass of Pectinatella the polyps are seen to be arranged, as seen in the spirit preparation, in close areolæ, which, being crowded and compressed together, often assume hexagonal outlines. From the periphery of these irregular areas the polyps project, the central part being as a rule unoccupied. When in the water the protrusion of the innumerable tentacles gives a fine velvety appearance to the surface, which entirely disappears on touching the polyps or agitating the water. This species is, however, much less timid than some others, and the polyps over even a small mass do not all withdraw on a slight irritation. The color of the polypidom is a light brown, or when the tententacles are extended, a faint rosy red hue, due to the color about the throat, glimmering through them. Towards the central part of the areolæ, white, brown and dark spots are seen, representing oval at various stages of development. The cœnœcium composed of the dense aggregation of polyps is closely united to the subjacent gelatinous mass, which constitutes here the ectocyst. On removal of the polyps the surface of the jelly presents patterns corresponding to the arrangement of the animals, irregular areas grooved in a radiate manner. The superficial portion of the ectocyst has often a reddish tint, and the deeper parts slightly greenish from the presence of a confervoid growth. Many masses of large size present a jelly perfectly colorless and pure throughout. Upon the development of this jelly, which is to be regarded as a definite excretion or secretion from the animal, the size of the polyp masses depends. When encrusting boards they are usually flat, larger conoidal projections occurring at intervals. Around the stems of rushes the most beautiful masses are found. The small one before you gives a good idea of the graceful symmetry of the growth. I have measurements of such a symmetrical cluster about a reed which was 14 inches in length and 10 in circumference, the weight 9 lbs. In some seasons the luxuriousness of the growth of these creatures is extraordinary. In the still quiet water in the marsh on either side of Desjardin canal, just before it passes through the Burlington heights, I have met with masses which would not go into a pail. The largest I have ever seen lay at

the bottom in about nine feet of water. I could hardly believe it was a mass of polyps, but, to satisfy my curiosity, I stripped and went in for it. With the greatest difficulty I brought it up in my arms, but could not get it out of the water for the weight, which must have been close upon 25 lbs. It resembled in form one of those beautiful masses known as brain coral.

On account of the colorless nature of the ectocyst and the extent to which the polyps protrude, this species is the most favorable to study the general arrangements of the organs, the perfect transparency allowing every detail in the structure to be seen. I have found it best to cut a thin vertical slice from the mass, containing on the surface not more than one or two rows of polyps, and examine in the zoophyte trough with a half-inch glass. It is much easier in this way to obtain a view of the complete animal than in the live box. The shock of the section and removal to the trough causes complete retraction of the polyps, and the surface of the cœnœcium looks smooth, or presents only slight tuberous elevations, corresponding to the situation of the orifices. On watching one of these, the sphincter closing it may be seen to relax, and the ends of the tentacles protrude through the orifice, feeling about from side to side as if to ascertain whether the "coast was clear." Finding no cause for alarm, the relaxation of the sphincter proceeds, the tentacles are pushed out still further, resulting at last in the complete evagination of the polyp. The beautiful crescentic tuft is arranged in the form of a horse shoe, or the letter U inverted, the tentacles spring from each side of the summit of the double outline, the mouth being at base. The number of the tentacles ranges from 50–80; they are sigmoid in outline and increase slightly in length at the extremities of the arms. The inner rows incline towards each other, the outer curve gracefully in the opposite direction. The surface of the tentacles is covered with cilia, which are in constant motion, creating a vortex, at the apex of which the mouth is situated. The tentacles act independently as well as in concert, and thrust and bend in any direction, pushing away objectionable matters which may have got into the throat, or are present in the neighbourhood. Frequently one of the large infusoria coming withing the vortex is carried down and attempting to escape is prevented by the interlacement of the tentacles which bending over form a cage. The sensitiveness of these ciliated arms is extreme and through them the creature obtains warning of approaching danger, and instantly withdraws itself.

From beneath the crescentic lophophore the alimentary canal hangs, which presents the following parts for observation: the epistome, a valve-like projection overhanging the mouth, the œsophagus or throat, the stomach, intestine and anus.

The epistome is a tongue-like organ arising at the junction of the inner arms of the lophophore, and serves as a valvular protection for the mouth. It possesses a set of muscles by which it can be readily moved and jerks up and down very frequently. It appears to keep materials in the throat rather than prevent the entrance of anything obnoxious. Like the tentacles it is covered with cilia. All the parts about the region of the espistome have a dark rose-red color, and this gives a peculiar brilliancy to the animals. A somewhat funnel-shaped mouth leads directly into the œsophagus, a short colorless tube, which widens slightly as it descends. A valve-like construction separates it from the stomach, into which, as soon as the œsophagus is full, the food is expelled by the contraction of the muscular walls.

The stomach forms an elongated tubular cavity in which the food is subject to a constant peristaltic action during the process of digestion. The lining membrane is plicated and the cells upon the folds are of a brown color, containing a fluid which Prof. Allman regards as a biliary secretion. The intestine or cœcum is a short broad cavity separated from stomach by a valve and placed parallel to the œsophagus, opening by an anal orifice immediately beneath the lophophore. The undigested residue of the food is gradually pushed through the cœcal valve and distends the intestine and is expelled by the contraction of the cœcal walls and carried away by the action of the cilia of the tentacles. From the lower part of the stomach a cord-like process, the funiculus, extends, and connects it with the bottom of the cœnœcium.

There is no definite circulatory system in the Polyzoa. A colorless fluid bathes the interior of the cœncœcium and the perigastric cavity. By the action of the cilia which line the interior of the cœnœcium currents are created which are rendered evident by the small particles carried round.

Respiration is probably carried on by the cilia covering the tentacles, but our knowledge of this function is extremely slight.

The nervous system of the fresh-water Polyzoa is represented by a definite ganglion which lies in the neighborhood of the

œsophagus, immediately below the epistome. It is easily seen in Pectinatella and presents curious contractions and expansions. By these the position of the mass is altered, sometimes approaching nearer the œsophagus, at others being in the hollow of the epistome. Nerve branches may be seen proceeding from this ganglion chiefly towards the epistome and tentacles.

The muscular system is well developed and the muscles form either sphincters or elongated branches. A definite sphincter surrounds the orifices of the cœnœcium and closes them tightly when the polyps are retracted, relaxing again for their protrusion. The longitudinal bands arise from the base of the cœnœcium, and passing up are distributed in three different localities, on the stomach, the base of the lophophore, and the tentacles, and are called respectively the gastric, lophophoric and brachial retractions. By the action of these muscles the little animal can be instantaneously withdrawn, and the sphincter closing effectually shields them from injury and attack. Other muscles are described by Hyatt and Allman, in connection with the epistome and endocyst.

The Phylactolœmata are reproduced by budding and true ovulation. From the side of the polyps buds arise which develope into mature forms and in this way the colonies are increased. Another method of budding results in the production of free gemmæ or statoblasts, which arise from the funiculus. These present a horny sheath, usually dark brown in colour, and an annulus or margin, which in some species is provided with spines. In Pectinatella, the spines number from 12–20, in Cristatella there is a double row, one shorter, the other longer, 50–60 in all, and the extremities are furnished with from 4–6 hooklets. The statoblasts float on the surface of the water and the armed ones get entangled in the weeds.

The method of production of true ova was first described by Allman. They originate in a bud-like mass at the upper side of the endocyst and are fertilized by spermatozoa, the testicles being an offshoot from the funiculus.

In the genus Plumatella I have determined three Canadian species, *arethusa*, *vitrea*, and *diffusa*. The members of this genus have dendritic, plant-like cœnœcia, which are firmly attached to the surface of submerged twigs, stones and water-plants. The cœnœcium is composed of little hollow branched tubules, divided into cells, from the apex of which the little polyp

protrudes, while at the other end it is in communication with the parent polyzoon. The branches are generally attached along the greater part of their length, though sometimes, as in this specimen of *P. arethusa*, they are free in nearly the whole extent. The color is owing to the ectocyst which when first secreted is thin and jelly like but soon becomes consistent, and at last dark brown. The endocyst lies immediately within this and is continuous throughout the system of branches.

The species of this genus are widely distributed throughout Canada in the quiet ponds and marshes attached to twigs, submerged logs and the under surface of the leaves of the water-lily.

The Cristatellidæ, the most highly organized of the Polyzoa, have a locomotive cœnœcium. There are two American species C. Idæ and C. ophidioidea. The one which I have studied here conforms to the latter, as described by Hyatt, in both statoblasts and number of tentacles. It is not nearly so common as the other forms. I have on several occasions met with the statoblasts in gatherings, but have never found the polyp except in the small lakes near the summer residence of Mr. G. W. Stephens, in the County of Maskinonge, Quebec. In Lac Rouge, the rocks at water's edge, at about the depth of from one to two feet presented numerous specimens about an inch and a half to two inches in length and one-third of an inch in breadth. The movement was slow, in those which I observed in a small basin, not more than an inch in the 24 hours. The statoblasts differ from those of Pectinatella in possessing a double row of hooklets with from two to six points.

NOTE.—I have received from the Rev. Thomas Hincks, the distinguished authority on British Polyzoa, a reprint from the Annals and Magazine of Natural History for March, 1880, entitled "On a supposed Pterobranchiate Polyzoon from Canada." It is based on a communication from his father, the late Professor Hincks, of Toronto University, in which a short account is given of a polyzoon found on a sunken boat in the Humber river, near Toronto. According to the description "the tentacles, instead of being disposed in a horse-shoe figure and forming a continuous series, as in the ordinary fresh-water species, are borne on two distinct erect lobes, which are separated at the base," the arrangement met with in the Pterobranchiate Polyzooa. At the date of Professor Hincks' letter, Dec. 1868, I was a student in his Natural History classes, and during the autumn of '68 had often

taken him specimens of various sorts, and among them a mass of Pectinatella, which I had found in an old submerged barge near the mouth of the Humber. I remember the fact very distinctly, as it was the first specimen of Pectinatella which I had found near Toronto, and Professor Hincks took a great interest in it, as he had not met with any fresh-water Polyzoa in Canada. Could this have been the specimen? It is a curious coincidence, to say the least, and perhaps in a look through the Museum of the University the specimen might be found, and the statoblasts would be sufficient to decide the question. Professor Hincks gives a sketch of the lophophore and it is hard to think that he could have been mistaken as he was an unusually skilful observer. The submerged barge was for many years a favorite collecting ground, and in some seasons Pectinatella was very abundant in the quiet water inside of it.

ON CERTAIN PARASITES IN THE BLOOD OF THE FROG.*

By William Osler, M.D., M.R.C.P., Lond.

Fellow of the Royal Microscopical Society of London, President of the Microscopical Society of Montreal, Professor of the Institutes of Medicine, McGill University.

In my Practical Histology class, during the winter of 1881–82, while the students were working at the blood of the frog (*Rana Mugiens*), I noticed in one of the slides a remarkable body like a flagellate infusorian. I thought that it was one which had got into the blood at the time of withdrawal, from the water on the web of the foot. Meeting with examples in the slides of several other students, my attention was again directed to it, and I made several sketches and wrote down the following description:—"Finely granular protoplasmic body, somewhat triangular in shape, about the size of a colorless corpuscle. The narrow end is prolonged into a cilium, while the other presents a broad band of rapidly undulating protoplasm, which at one angle is prolonged into a long lash-like process. The undulating fringe and the cilia are in constant motion, giving the appearance of rapid waves passing from one corner to the other, the waves of protoplasm gradually increasing in length and tenuity until they have the appearance of projecting cilia.

---

* Read before the Montreal Microscopical Society.

No nucleus can be seen. Though in constant action no change of locality takes place." Fig. 1.

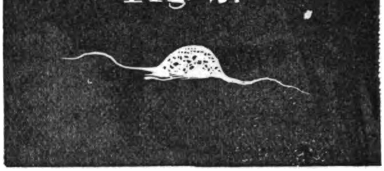
Fig. I.

On looking up the subject I found that the little organism was the *Trypanosoma sanguinis* which had been described originally by Gruby as an entozoon in the blood of frogs, and by Ray Lankester (not at the time knowing Gruby's observations) as *Undulina*, the type of a new group of Infusoria.

Though a trifling little object it possesses considerable interest as there is still a doubt concerning its real nature and the movement which it displays is unusual, being neither the slow, creeping rhizopodal motion, nor yet truly ciliary. Minute protoplasmic organisms usually display one or other of these types of movement, but in the object under consideration, there is a peculiar wavy undulation along one margin of the creature together with a lashing vibratile action. Studying the margin under a high power a rapidly succeeding series of waves is seen to pass from one side to the other, increasing in length until at one corner the wave is extended into a lengthened cilium resembling the whip-like flagellum of an infusorian. In the specimens which I examined the undulations always passed in one direction and it appeared as if from the tips of any of the waves the protoplasm could be extended into cilia, though usually only those at one end presented them. It is this latter feature, together with the peculiar wavy character of the motion that gives the creature a special interest and makes it quite an exceptional one among organisms of its class. A fine hair-like extension from the narrow end was also in constant motion and appeared to vary considerably in length, as if it were only a delicate process of the protoplasm, and, unlike a true *cilium*, capable of elongation or retraction. I kept one under observation for over an hour, during which time the movements kept up, but got slower towards the close. The undulatory motion at last ceased, but the tail-like

projection and the flagellum at the margin of the broad end continued to move (the appearance is represented at fig. 2.)

Fig. 2.



and were evident after motion had ceased. This would favor the view that these processes were "cilia," and not merely temporary extensions of the protoplasm, though the remarkable manner in which the cilia were extended and retracted shows that they were not similar in all respects to the cilia of Infusoria or of various animal cells. Professor Lankester speaks of it as "a mouthless infusorian, closely allied to Opalinidæ, from which, however, it differs essentially, as well as from *Infusoria ciliata* generally in possessing no cilia." Gruby described it as a parasitic entozoon, while Siebold * states that it is not an independent organism, but simply an undulating membrane swiming freely. Dr. Gaule † has advancad some rather startling views concerning this little body which he believes originates in, or is a transformation of a colorless blood cospuscle. He states that on the warm stage the process of conversion of the white blood corpusele into the *Trypanosoma* may be readily followed and takes place by the development at one margin of a vibratile cilium and a rapidly undulating membrane. He recognized four or five types of these transformed blood corpuscles and calls them "Kymatocytes." They may return to their original corpuscular condition. I have tried to follow these observations of Gaule but without success and adhere to the opinion that we have to deal here with a minute parasite, the affinities and life history of which have yet to be worked out. They were not abundant in the blood of my frogs and were only met with in two. I have not found them this season in any of the frogs in my tanks.

This session my attention was called by a member of my Histology class to what he thought was a peculiarly elongated white corpuscle in the frog's blood, but which I recognized as another

* Micrographic Dictionary—Undulating Membranes.
† Arch. f. Anat. u. Physiol. (Phy. Abt.) 1880.

parasitic form. The blood examined by the student on that day was taken from two bull frogs (*Rana Mugiens*), but only one contained the parasites. The organism presents the following characters:—Body an elongated oval, sausage-shaped, ends conical, one sometimes narrow and prolonged. Length somewhat more than half a red corpuscle. The protoplasm is homogeneous and more translucent than that of colorless corpuscles and shows two or more small central vacuoles (?) with a few granules. Movements slow and creeping, accompanied by an occasional bend or twist of the body, go on at ordinary temperature; a little accelerated but not altered in character on the warm stage. The tail-like end though produced does not terminate in a cilium. Fig. 3.

Fig. 3.

This parasite was originally figured by Ray Lankester, when describing the Undulina (Trypanosoma) but he has only recently, in the *Quarterly Journal of Microscopical Science*, for January, 1882, given a full description of it, and established its position. He calls it *Drepanidium ranarum*. Dr. Gaule, of Leipzic, has studied these bodies and has come to conclusions as remarkable as those at which he arrived concerning *Trypanosoma*. He calls them "Wurmchen," *vermicles*, and believes that they are protoplasmic portions of the corpuscles of the blood which assume an elongated form and display movements. He has found them within the cells not only of the blood but of the spleen, kidney and liver and has seen them penetrate and enter blood corpuscles by their active movement.

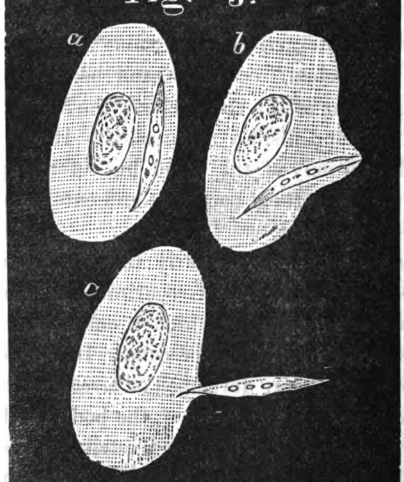
Dr. Lankester shows very clearly that these organisms are truly parasites belonging to the Gregarinidæ or Sporozoa, those lowly protozoal forms, many of which at some time of their existence are parasitic in the interior of cells. He suggests that it is a young stage and the more developed or Gregariniform condition of the parasite exists in some part of the body of the frog. He points out that these bodies have a striking resemblance to those figured by Lieberkühn, as spores or pseudo-navicula from

the kidney of the frog. Within the cells they can best be seen on the addition of salt solution 3%. I have found, after trying a number of solutions, that Pilocarpin ½% brings them out very clearly. In one frog the red corpuscles contained, in addition to the Drepanidia, smaller irregular masses, fig 4.

Fig. 4.

In blood from a small frog they were very abundant, and could be seen well without any reagent. Fig. 5 *a* represents a corpuscle with one inside which travelled round the cell four or five times, and then migrated from it as shown at Figs. 5 *b* and *c*. This curious phenomenon was witnessed several times, and did not seem to injure the corpuscles very much, some presenting no trace of the point of exit, others a slight depression.

Fig. 5.



PRELIMINARY NOTICE OF NEW FOSSILS FROM THE LOWER CARBONIFEROUS LIMESTONES OF NOVA SCOTIA AND NEWFOUNDLAND.

By J. W. Dawson, LL.D., F.R.S.

I.—NOVA SCOTIA.

The following are specimens from the collections of Dr. Dawson, made in Nova Scotia and now in the Peter Redpath Museum, and which are either undescribed or serve farther to illustrate species described in the author's Acadian Geology.

Discites Hartti, Dawson.

[*Gyroceras Hartti*, Acadian Geology.]

The original description of this species in Acadian Geology (page 311) was based on a specimen showing the outer or body chamber only, and this from its form was at the time (1868) supposed to be referable to the genus *Gyroceras*. I have, however, recently collected at Brookfield additional specimens, which throw new light on its structure and affinities. The species may now be described as follows.—

Form discoidal, apparently with an open umbilicus. Whorls with the dorsal side flat or nearly so. This flat space is separated on each side by a shallow furrow from a strong latero-dorsal ridge, and this by a broader shallow depression from the umbilical ridge, which in some specimens seems to be divided into two by a very slight medial depressed line. Siphuncle small and sub-central, being nearer the dorsal than the ventral side; septa slightly angulated at the latero-dorsal ridge. Body-chamber with slight transverse rugae. Aperture projecting at the latero-dorsal ridge and receding at the umbilical ridge into a deep sinus. Diameter of largest specimen, apparently adult, 2.5 centimetres.

This species may be compared with *Nautilus* (*Trematodiscus*) *trisculcatus* M. & W. (Illinois Report, Vol. II.) or with *N.* (*Discites*) *sulcatus*, Sby. As the characters on which the first named authors rely for separating their genus *Trematodiscus* from *Discites* are somewhat vague and scarcely apply to the pre-

sent species, I think it well to place it in the genus or sub-genus *Discites* of McCoy; remarking, however, that it might be included in *Trematodiscus*, should that sub-genus be sustained.

LOXONEMA CARA, S.N.

Shell small, elongate. surface polished and shining, volutions about eight, regularly curved and marked by about thirty thin vertical ridges crossing the whole of each volution. Aperture apparently regularly oval. Length 7 millimeters, breadth at second turn 2 millimetres. It somewhat resembles a species figured but not named in Worthen's Illinois Reports, Vol. V, Plate XXIX, fig. 3.

This beautiful little shell was found by Mr. W. Gurley, of Danville, Illinois, in specimens of limestone from Windsor, Nova Scotia, and was by him kindly communicated to the writer.

PLEUROTOMARIA ACADICA, S.N.

Somewhat elongate, volutions four, nearly horizontal at the suture and bending downward at a right angle, giving them a square section, especially in the lower volutions. On the body whorl the angle between the upper and lateral surfaces forms a distinct ridge. Surface otherwise quite smooth. Length 4 millimetres. It is allied to *P. Chesterensis* of Meek and Worthen and to *P. altivittata* of McCoy.

From collections made by Prof. Hartt, at Windsor, Nova Scotia.

SANGUINOLITES BROOKFIELDIANUS, S.N.

Among my specimens from the Lower Carboniferous Limestones of Nova Scotia, there have been for many years casts and fragments of a bivalve shell of the above genus, but too imperfect for description. In a recent visit to Brookfield I obtained better specimens, and now venture to describe the species as follows:—

Shell more than twice as large as wide, anterior end regularly rounded, hinge line straight, ventral line slightly and regularly curved, posterior end sub-truncate. An oblique ridge extends from the beak to the latero-posterior angle. In front of this ridge the sides are marked with unequal concentric ridges of growth, behind it the surface is smooth, but in well-preserved specimens shows two slender longitudinal ridges dividing the

triangular space into three equal parts. There are indications of a slight internal transverse rib near the anterior end, suggesting affinities with King's genus *Pleurophorus*. It is nearly allied to *S. plicatus* of McCoy. Length of the largest specimen 3.5 centimetres.

Lower Carboniferous Limestones at Brookfield and Windsor.

Aviculopecten Lyelli, (var. *alternans*.)

In describing the Aviculopectens of the Lower Carboniferous (Acadian Geology, pp. 305 to 307), I have mentioned specimens resembling *A. Lyelli*, but larger and more coarsely marked, and which I compared with *A. plicatus* of Sowerby. Many additional specimens of these shells, collected from time to time, appear to show gradations connecting them with the typical *A. Lyelli*, which they perfectly resemble in general form and general style of markings, but differ in larger size and in having broader ribs, nodose rather than squamous, and generally showing toward the edge alternations of coarser and finer ribs. The larger and more characteristic specimens of this form might readily be considered distinct; but intermediate forms seem to show that there is no specific distinction. My best specimens are from the limestones of Brookfield and the Shubenacadie.

Berenicea insueta, s.n.

Group of cells oval, about one millimetre in length and somewhat raised in the centre; on the dorsal valve of a shell of *Athyris subtilita*. Cells round, spirally arranged, somewhat oblique to the surface. Spaces between cells granular. About ten cells in the length of the group.

Encrusting *Polyzoa* of this kind appear to be rare in the Carboniferous limestones of Nova Scotia. The present species occurs in Prof. Hartt's collection from Windsor.

Megastroma laminosum, s.n.

Broadly expanded layers about one millimetre in thickness, and two millimetres or more apart. Each layer consists of a double membrane, beset with numerous spicules pointing inwards and looking like two brushes facing each other. The membranes are penetrated by openings or oscula, and appear to be porous or reticulate in their substance and to have cellular thickenings in places, giving them a peculiar appearance. The layers sometimes

though rarely unite, and are sometimes not continuous when seen in section ; this appearance being perhaps produced by large openings or spaces. In each layer the ends of the opposing spicules are sometimes in contact, sometimes separated by a space, empty or filled with calcite. The intervals between the layers are occupied by organic limestone, consisting of small shells and fragments of shells and corals. As many as twelve or thirteen layers are sometimes superimposed, and their horizontal extent seems to amount to a foot or more. The layers have a deep brown color, while the enclosing limestone is of a light gray tint.

This remarkable body was found in the fossiliferous limestone of Brookfield, in patches parallel with the stratification, and at first sight resembled a coarse *Stromatopora*. When sliced and examined under the microscope, it presents the appearance above described The membranes referred to, from their deep brown color would seem to have been of a horny or chitinous character. They are sometimes bent and folded, as if by pressure, and appears to have been of a flexible and tough consistency. The spicules connected with it, if really organic, would seem to have been set in the membrane, and to have been corneous rather than silicious. I have, however, no absolute certainty that these apparent spicules may not be rather the effect of prismatic crystals of calcareous spar penetrating a soft animal matter and impressing on it their own structure. If the spicules are really organic, the structure must be of the nature of a sponge. If otherwise, it must have consisted of double membranous layers enclosing between them a softer organic matter, and sufficiently firm to retain their form till filled in with calcareous fragments. Unless the structure was of vegetable origin, which I do not think likely, it was probably a Protozoan of some kind. In either case it is different from any fossil hitherto found in the Lower Carboniferous limestones of Nova Scotia.

II.—NEWFOUNDLAND.

The following species are contained in limestone from Port-au-Port and other places in St. George's Bay. Newfoundland, collected by Dr. Robert Bell and Mr. P. Patterson, and now in the Peter Redpath Museum. The limestone is similar lithologically to that of Brookfield, Windsor, and other places in Nova Scotia, and the greater part of the fossils are common to Newfoundland and Nova Scotia.

SERPULITES MURRAYI, S.N.

Tube cylindrical, slightly curved in the part preserved, smooth, with indications of a thin shell. Diameter of largest specimen 14 millimetres at the larger end and 11 millimetres at the smaller end. Length 10 centimetres. Several fragments of smaller size may belong to young individuals or to the terminal portions of adults.

This tubular cast, destitute as it is of the outer shell, can scarcely be referred with certainty to the serpulæ. It might have belonged to a mollusk; but in the mean time may be provisionally referred to *Serpulites*. The specimens are from Dr. Bell's collection at Port-au-Port. Dedicated to Alex. Murray, C.M.G., F.G.S.; Director of the Geological Survey of Newfoundland.

MACROCHEILUS TERRANOVICUS, S.N.

Shell conical in form, with five volutions strongly shouldered and with deep suture, each turn becoming one-third smaller than that below. Lower volutions each with 12 to 13 vertical ribs, more strongly marked at the suture and fading below. Aperture ovate, rounded in front, slightly angled behind. Umbilicus small. Length 8 millimetres.

Very abundant in some specimens in Dr. Bell's collections from St. George's Bay. A little shell found very abundantly at Pugwash, Nova Scotia, and referred in Acadian Geology (p. 309) to the genus *Turbo*, probably belongs this genus. It differs from the present species in having as many as twenty folds in the suture.

PTERONITES GAYENSIS (var. *ornatus*).

General form of shell similar to that of *Pt. Gayensis* (Acadian Geology p. 301), but differs in its somewhat larger size and in the ornamentation of the whole shell with delicate raised concentric lines instead of obscure rounded wrinkles. The left beak is considerably more prominent than the right, the hinge line slightly curved inward, and the ridge along it well marked. Length of shell one centimetre. Port-au-Port, Newfoundland, collections of Dr. Bell and Mr. Paterson.

I should have been disposed to regard this shell as a distinct species, but for the fact that there is a probability that the Gay's River specimens have lost their finer ornamentation, and that

several of the shells common to Newfoundland and Nova Scotia show a larger size and better development in the more northern locality.

With the above species are the following, already described in Acadian Geology, as found in the Lower Carboniferous of Nova Scotia:—

Serpulites annulatus, Dawson.
Conularia planicostata, Do.
Aviculopecten Debertianus, Do.
Bakevellia antiqua, Munst.
Cypricardia sp.
Terebratula sacculus, Martin.
Spirifera glabra.
Productus semireticulatus, Martin.
P. Cora, D'Orbigny.
Streptorhynchus crenistria, Phillips.

ALPINE FLORA OF THE PROVINCE OF QUEBEC.

By J. A. ALLEN, New Haven, Conn.

In the summer of 1881 I joined a party which visited the eastern portion of the Shickshock Mountains, in Gaspé County. Although only about 4000 feet high, these mountains have a more extensive treeless area than the White Mountains, and many patches of snow remained on them at the beginning of August. Below is given a list of some of their plants, and of a few from the south shore of the Lower St. Lawrence. The willows were named by Mr. Bebb, some of the grasses by Dr. Vasey, and some of the other plants by Mr. Watson.

The following were collected on Mount Albert:—

Ranunculus affinis, R. Br. var. leiocarpus, Trautv.
Arabis alpina, L.
Viola palustris, L.
Silene acaulis, L.
Lychnis alpina, L.
Arenaria arctica, Stev.
A. verna, L.
A. verna, L. var. hirta, Wats.
A verna, L. var. rubella, Hook.
Sibbaldia procumbens, L.
Parnassia Kotzebuei, Cham. and Schl.
Epilobium origanifolium, Lam.
Solidago Virga-aurea, L. var. alpina, Bigel.
Gnaphalium sylvaticum, L. var. norvegicum, Gunn.
Arnica mollis, Hook.
Nabalus nanus, D. C.
Vaccinium cæspitosum, Mx.
V. ovalifolium, Smith.
V. uliginosum, L.
Arctostaphylos alpina, Spreng.
Cassiope hypnoides, Don.
Bryanthus taxifolius, Gray.
Rhododendron Lapponicum, Wahl.
Loiseleuria procumbens, Desv.
Pyrola secunda, L. var. pumila, Paine.
Diapensia Lapponica, L.
Armeria vulgaris, Willd.

Veronica alpina, L.
Castilleia pallida, Kunth. var. septentrionalis, Gray.
Oxyria digyna, Campdera.
Comandra livida, Richardson.
Betula glandulosa, Mx.
Salix arctica, Br. var. Brownii, Anders.
S. chlorophylla, Anders.
S. Cutleri, Tuckerm.
S. desertorum, Richards.
S. herbacea, L.
Juniperus communis, L. var. alpina, L.
Goodyera Menziesii, Lindl.
Juncus trifidus, L.
Scirpus caespitosus, L.
Eriophorum russeolum, Fr.
Carex rigida, Good.
C. scirpoidea, Mx.
Phleum alpinum, L.
Poa alpina, L,
Festuca scabrella, Torr.
Aira atropurpurea, Wahl.
Hierochloa alpina, Roem. and Schul.
Danthonia sericea, Nutt.
Pellaea densa, Hook.
Asplenium viride, Huds.
Aspidum aculeatum, Swz. var. Braunii, Koch.
A. aculeatum, Swz. var. scopulinum, Eaton.
A. fragrans, Swz.
Cystopteris montana, Bernh.
Lycopodium alpinum, L.
Lycopodium Selago, L.
Selaginella selaginoides, Link.

Table-topped Mountain affords in addition :—
Draba androsacea, Wahl.
Cerastium trigynum, Vill.
Lonicera involucrata, Banks.
Salix argyrocarpa, Anders.
S. vestita, Pursh.
Luzula arcuata, Meyer.
Carex rariflora, Smith.
Calamagrostis Langsdorffii, Trin.
Woodsia glabella, R. Br.

Some northern plants occur both on the coast and mountains, as

Artemisia canadensis, Michx.
Rhinanthus Crista-galli, L.
Polygonum viviparum, L.
Carex atrata, L.
C. Capillaris, L.,
C. voginata, Tausch.

The following grow on the shores of the Ste. Anne River.

Anemone parviflora, Mx.
Dryas octopetala, L. var. Drummondii, Watson.
Solidago bicolor, L. var. concolor.
Graphephorum melicoides, Beauv.
Poa caesia, Smith.
Woodsia hyperborea, R. Br.

Near Ste. Anne des Monts on the coast were found:

Stellaria longipes Goldie. var. Edwardsii, Watson.
Montia fontana, L.
Parnassia parviflora, D. C.
Hippuris maritima, Hellenius.
Arnica alpina, Murray
Gentiana Amarella, L. var. acuta, Hook. f.
Pleurogyne rotata, Griseb.
Spiranthes Romanzoviana, Cham.
Zygadenus glacus, Nutt.
Carex gynocrates, Wormsk.

Near Matane were collected :

Astragalus oroboides, Hornem. var. Americanus, Gray.
Epilobium latifolium, L.
Pedicularis palustris, L. var. Wlassoviana, Bunge.
Plantago eriopoda, Torr.
Rumex salicifolius, Weinm.
Blysmus rufus Link.
Carex norvegica, Schk.,

THE GEOLOGY OF PORT HENRY, NEW YORK.*

By T. Sterry Hunt, LL.D., F.R.S.

Port Henry, in Essex County, is well known as a locality where the highly inclined Laurentian gneisses, with their associated limestones and iron ores, rise from beneath the nearly horizontal paleozoic strata of the Champplain valley. The gneiss just above the Port Henry iron-furnaces presents alternations of lighter feldspathic and darker hornblendic beds with others highly quartzose, and includes layers of a sulphurous magnetite which are, however, insignificant when compared with the great deposit of this ore mined at Mount Moriah, in the vicinity. Near by is seen a considerable breadth of white crystalline somewhat graphitic limestone, along the eastern border of which are three smaller beds of two or three feet each, of the same rock, interstratified with layers of crumbling gneiss.

Half a mile southward, near the town, a quarry is opened in a more coarsely crystalline limestone, in which, as seen in 1877, were enclosed irregular masses and layers of the adjacent gneiss, sometimes transversely broken, but scarcely separated, and from two to three inches in thickness, though sometimes much larger. The limestone was marked by lighter and darker bands, containing more or less graphite and pyrites, and in parts held coarsely crystalline sphene and green pyroxene, in layers. We have here one of those cases which led Emmons and Mather to assert the eruptive character of these limestones, and it is probably a similar instance which lately led an eminent geologist to describe crystalline limestones in this region as overlying unconformably the gneisses. The phenomenon, in the writer's opinion, is one which he has elsewhere described at length, namely the occurrence of great calcareous veinstones, which hold the characteristic minerals of the adjacent interbedded limestones, and like granitic and metalliferous veinstones, have been deposited from solutions

* This note is an abstract of a paper read before the American Association for the Advancement of Science, at Saratoga, in August, 1879, but, through an oversight. not then published. As it contains some matters of interest to geologists, I send the note as then written, without change, to the *Canadian Naturalist.*—T. S. H , January, 1883.

in the fissures of the broken gneissic strata, and are not unfrequently brecciated, as in the present case. These calcareous masses are not eruptive but endogenous. The Laurentian rocks abound in similar instances. (*Second Geol. Survey of Penn.*, Report E, pp. 166, 167.)

A few miles north from Port Henry the gneiss, with its magnetites, is replaced by the massive bedded labradoritic rocks of the Norian series (the hypersthene rocks of Emmons) with great masses of titanic iron-ore, which latter abound near Westport. Prof. Hall has described these rocks as newer and unconformable with the underlying gneiss; which accords with the numerous observations of the relations of these two series made in Canada. The Norian rocks are well displayed along the railway between Westport and Port Kent, where a nearly continuous cutting of about five miles through them, around Willlsborough Bay, affords a good opportunity for their study. Prof. Leeds has lately published a valuable series of chemical and microscopical studies of the Norian rocks of this region.

The Potsdam sandstone, the basal member of the overlying paleozoic series is well seen in a railway-cutting at Port Henry. The lower beds are massive and compact, dark bluish or iron-gray, with lighter bands and thin blackish shaly layers. Dipping gently to the northward, they become overlaid by the higher beds of the division, which are light gray and porous, and composed apparently of agglutinated silicious grains, as if deposited from solution, as long ago remarked by Prof. Hall for the similar strata of Iowa. Some of those upper layers have irregular cavities, as if from the disappearance of organic remains, and others exhibit numerous vertical cylindrical markings differing alike from the *Scolithus linearis* of the Primal sandstone and the *S. Canadensis* of the Potsdam of the Ottawa basin. The markings at Port Henry are small vertical cylindrical cavities, often eight or ten centimetres in length and about three millimetres in diameter; having a concentric interior tube or cylinder of about two millimetres external and one millimetre internal diameter, and sometimes exhibiting traces of concentric layers. Farther study is needed to determine the origin of these markings which I have elsewhere described. (*Second Geol. Survey of Penn.*, Report E, p. 138.)

Above these sandstones are seen massive layers of an impure dark bluish limestone without observed fossils, holding eighteen

per cent. of magnesia, and probably representing the so-called Calciferous sandrock, which is really an impure dolomite. As seen along the railway, these beds have at first a very gentle dip to the northward, which soon grows steeper until, where lost sight of, a few hundred feet from the wall of gneiss, they dip towards it with an angle of about sixty degrees to the northwest. The almost constant eastward dip of the paleozoic strata on the east side of the Champlain and Hudson valleys, as a result of which the newer seem to pass below the older and more crystalline rocks, is well known. It is easy to conceive that lateral pressure, from the contraction of the earth, acting upon horizontal strata deposited against a barrier of older and resisting rocks, may, according to circumstances, either cause them, by the sliding of their edges. to be raised up and made to dip away from the older rocks (a case frequently met with)—or else, the edges remaining fixed, the compressed strata beyond will be upraised in one or more folds (which may even be over-turned) often with faulting, so that the proximate portions are made to dip towards the resisting barrier. This condition, as was well shown by H. D. Rogers, is seen in the Primal and Auroral strata along the north-west base of the South Mountain in the great Appalachian valley. We have here at Port Henry apparently an example, on a small scale, of the same phenomenon on the opposite side of the valley, and against the southeast base of an ancient barrier of Laurentian gneiss.

NOTES ON THE MORE IMPORTANT COAL SEAMS OF THE BOW AND BELLY RIVER DISTRICTS.

By George M. Dawson, D.S., F.G.S., Associate Royal School of Mines.

The fuels contained in the rocks of the Bow and Belly River districts vary from lignites, but slightly superior in quality to those of the Souris region, to materials containing a very small percentage of water, forming a strong coke on heating, yielding abundance of highly luminous hydrocarbons, and precisely resembling ordinary bituminous coals, though of Cretaceous or Laramie age. In describing them the general term *coal* will be used, as it is impossible to draw a definite line between the two classes among the numerous intermediate varieties.

A seam of coal of good quality occurring on the lower Bow and Belly Rivers, is seen in the banks for many miles at a varying height above the water, owing to the light undulating dips by which it is affected. It is generally not more than a foot or eighteen inches in thickness though so persistent in extent, but at one point on the Belly River it thickens to three feet, forming a workable seam, which appears to be of good quality throughout. This locality is thirty-two miles in a direct line from "Coal Banks." No analysis has yet been made of this fuel.

The locality just referred to as "Coal Banks" is at the crossing of the Belly River by the trail to Benton. The coal occurring at this place is that which has been described as existing at the base of the Pierre. It is one of the best in the district, and has been worked to a small extent for some years at this point by Mr. N. Sheran. The outcrop of this seam is now known to extend from a point about six miles up the St. Mary River to that part of the Belly near and below Coal Banks, and then to run northward to the Bow River. South of the point indicated on the St. Mary River, it has not yet been traced, but as it appears remarkably constant in thickness and general character, both here and at the Bow River, sixty-six miles distant, it doubtless extends considerably further in each direction, and may also be assumed to underlie the plains between the Belly and Bow Rivers in workable thickness.

The drift deposits average about one hundred feet in thickness over this part of the plains, and it is consequently, in general,

only in the river valley or in the larger coulées which flow into them that the Cretaceous rocks can be seen. The Belly Valley in this part of its course is about 300 feet deep, and averages nearly a mile in width. It therefore cuts about 200 feet into the Cretaceous rocks, and displays fine sections of these. There are in this vicinity several associated coal seams; one of these, that which has been opened by Mr. Sheran, I may, for the sake of clearness, refer to as the "main coal." It is more or less perfectly exposed at intervals along this part of the Belly for a distance of about twelve miles, or from the working at Coal Banks to Big Island of the map. Above the Coal Banks the measures are affected by a light anticlinal swell which brings up older rocks, and the outcrop runs round by the west, appearing on the river again at the mouth of the St. Mary. At the furthest point up the St. Mary, where the coal appears (almost seven miles from the mouth of the river), it shows the following sections, the second column being a continuation of the first at a spot about 100 yards further down stream:—

	ft.	in.
Rusty ironstone layer	0	8
Blackish and rusty shale	5	0
Coal	0	3
Blackish shale	6	0
Coal	0	6
Soft carbonaceous shale	0	4
Coal	0	8
Soft, thin shale, highly carbonaceous in upper part	0	6
Ironstone shale	0	6
Blackish shale	3	0
Coal	0	8
Carbonaceous shale (some coal)	1	6
Coal (partly below water	1	6

	ft.	in.
Coal	1	0
Shaly coal	0	6
Coal	1	3
Shale	0	2
Coal	0	9
Grey shale	4	0
Coal	1	4
Grey shale (to water)	4	0

About two miles further down the St. Mary the coals are again seen, with the following development:—

Coal (rather shaly)	1	0
Coal	1	5
Shale	0	3
Coal	0	9
Shale	10	1
Coal	3	8
Shale (with obscure plant impressions)	6	0

At the mouth of the St. Mary the main seam has a thickness of three feet six inches, but about eighteen inches at the top is rather shaly.

On comparing these sections on the St. Mary with those at Coal Banks and on the Belly River to the north, it will be noticed that the coal at the first-mentioned locality is more divided by shales and less favourably situated for working.

On the part of the Belly River near Coal Banks the measures have, as a whole, a light westerly dip, while that part of the outcrop between Coal Banks and Big Island forms a minor synclinal hollow in its edge, across which the river cuts in a direction nearly coinciding with the main strike of the measures, and gives rise to a great display of coal on this part of the valley. The coal-bearing horizon, as above mentioned, lies at the base of the Pierre, and its position between the dark shales of this formation and the pale sandy beds of that underlying it, renders it easy to define the situation of the coals, even where their actual outcrop is concealed. For a distance of five miles north of the Coal Banks exposures, the dark shales just referred to occupy the river valley, while the outcrop of the coal is carried eastward to an uncertain distance by the light synclinal undulation above referred to. The gentle inclination of the measures shows that the coal might be reached at a moderate depth by shafts sunk through the dark shales in this part of the valley, from which it might with facility be worked up its slope to the eastward. The undulating character of the dips renders it impossible to estimate the exact depth at which the seam would be found, but it is probably not over 500 feet below the river, midway between its southern and northern outcrops in the valley. It may also be worked on a smaller scale, but with great facility, by levels driven into the actual outcrops in the river banks.

Having thus briefly described the general mode of occurrence of the coal on this part of the Belly River, the following more detailed notes on the outcrops which occur will serve to show the actual character of the seam.

At the Coal Banks, the coal has been extracted chiefly by quarrying along the natural outcrop, though during the past summer a small level has been begun. The outcrop is situated in the front of a steep scarped bank facing the river, and the seam, which at the southern end of the bank is about 30 feet above the water, dips away below the water at the northern. The fol-

lowing section shows the mode of occurrence and association of the coal in the bank, but does not extend upward to the base of the drift deposits :—

		ft.	in.	
	Finely laminated grey shale	8	0	
	Coal (shaly below)	1	6	
	Grey, thin-bedded shale	12	0	
	Ironstone	0	3	
	Grey shale	1	9	
	Coal	0	8	
	Grey shale and nodular sandstone, carbonaceous below	7	0	
Main seam.	*Coal*	1	4	Coal, 5′ 4″
	Shaly parting (often almost absent)	0	4	
	Coal	4	0	
	Carbonaceous shale	2	0	
	Grey shale	2	0	
	Ironstone	0	4	
	Greyish and brownish shale	3	0	
	Carbonaceous shale	3	0	
	Coaly shale	0	8	
	Grey shale	2	0	
	Coal	0	4	
	Carbonaceous shale (to water)	1	4	

The dip at this place is about N. 83° W. (mag.), at an angle of 5 to 8 degrees.

On the opposite side of the river, at the next bend, the coal seam is again well shown. It is slightly undulating, and dips gradually away below the water level at the northern end of the bank. The part of the section designated above as the Main Seam is here as follows :—

	ft.	in.
Coal	1	6
Shaly parting (1 to 3 inches)	0	2
Coal	3	3
Total coal	4	9

About four inches in thickness at the base of the seam is here laminated in texture, but appears nevertheless to be of good quality. The general dip is about N. 50° W. (mag.), at an angle of less than 5°.

From this point for a distance of five miles down the valley, the dark shales overlying the coal are alone seen. When it

again appears, in the west bank of the river. the Main Seam shows the following section:—

	ft.	in.
Coal	1	6
Shale	0	3
Coal	4	6
Shale	1	6
Coal	2	9
Total coal	8	9

The lowest division of the seam at this place is apparently not represented in the sections previously described. The coal in it is somewhat laminated, but seems to be of good quality. The dip is here about S. 70° W. (mag.) at at angle of 5°.

About three miles further north, extensive exposures of the coal are again found in the scarped bank or cliff facing the river, at a height of about 100 feet above the water level. The dip is light and undulating, but on the whole westward, or away from the river. The Main Seam is here composed as follows:—

	ft.	in.
Coal	2	6
Carbonaceous shale	0	7
Coal	2	2
Carbonaceous shale	1	0
Coal	1	3
Total coal	5	11

The coal here appears to be of good quality throughout. North of this point on the river the Main Seam is not again found well exposed, though in several places the associated rocks are shown in such a way as to indicate that it outcrops below the drift a short distance east of the river valley.

At the point at which the base of the Pierre should cross the Little Bow River, a seam of coal a few inches thick was observed, but the exposures did not bring the main seam into view.

The coal-bearing horizon appears again on the Bow River at Grassy Island, about thirty-three miles in a direct line below the Blackfoot Crossing, at lat. 50° 25′ 15″. In their general appearance, arrangement and thickness, the seams here exposed closely correspond with those on the Belly River. The subjoined sections exhibits the relations of the coal at this place:—

	ft.	in.
Lead grey shale	25	0
Coal	1	6
Soft grey and yellowish-grey shaly sandstone	13	0
Carbonaceous shale, coaly streaks	2	3
Coal (good and sound throughout)	4	6
Dark grey shale and shaly clay	7	0
Coal	1	0
Carbonaceous shale	1	0
Coal	0	8
Soft shale and clay	8	0
Coal and carbonaceous shale (to water)	1	6

The seams dip westward at a very light and constant angle. The seam four feet six inches in thickness probably represents the Main Seam of the Belly River.

Some general facts regarding the composition of the coal of this horizon in the Cretaceous may be given. The analysis by Prof. Haanel quoted in my report on the Geology and Resources of the 49th Parallel (p. 179, No. III, in table) is of coal from this seam, but probably from that part of the outcrop near the mouth of the St. Mary River. The same remark applies to a specimen which was analysed by Dr. Harrington. (Report of Progress, 1877-78, 49 C.) Prof. Haanel's analysis shows 6.69 per cent. of moisture and 6.36 per cent. ash. Dr. Harrington's specimen contained 5.79 per cent. water and 2.05 ash. A specimen from Mr. Sheran's mine, collected and examined by myself, yielded the following result :—

Water	6.52
Volatile combustible matter	31.03
Fixed carbon	56.54
Ash	5.91
	100.00

The coal is compact, does not easily break up by handling or exposure, and is in every respect a very excellent fuel, but does not yield a coherent coke.

In correspondence with the increased distance from the mountains of the outcrop of the same seam on the Bow River, and probable inferior degree of alteration to which it has been subjected, the coal is there found to contain more water, approximating in this respect to some of the Souris River lignites. From these, however, it still differs in its more compact texture and resistance to weathering and the regular vertical cleat or jointage

planes by which it is traversed, which cause it to assume cuboidal instead of conchoidal forms on fracture. A preliminary examination of an outcrop specimen from the locality gave the following result:—

Water	12.37
Volatile combustible matter	32.33
Fixed carbon	46.39
Ash	8.91
	100.00

The seam occurring at the summit of the Pierre formation on the Bow River, and the point which I have designated as Horse-shoe bend, has a very light westerly or north-westerly dip, and is not known to be represented on the Belly River, though it is probably its continuation which appears on the Little Bow, near the mouth of the Snake Valley. The outcrop of Horse-shoe bend is situated about fifteen miles east-north-east of the Black-foot Crossing. The seam appears at a height of 135 feet above the river, and is exposed for nearly half a mile. It is four feet four inches in thickness, compact and hard where not long weathered, and in physical character resembles that last described. A preliminary examination of an outcrop specimen showed the following composition:—

Water	13.67
Volatile combustible matter	37.16
Fixed carbon	40.50
Ash (reddish)	8.67
	100.00

Still following an ascending order in the series, the seam which has been known for some years at Blackfoot Crossing next claims attention. This is several feet higher in the section than the last, and is distinctly included in the Laramie. It is probable that still another seam exists between this and that last described, but no good sections of it were found.

Coal occurs in several places on the Bow River a few miles above the Blackfoot Crossing. The seams are too thin to work, but are probably on the same horizon with that described below. Throughout this region the beds are affected by gentle undulating dips, and though they have besides a very light general inclination westward, they may be considered as practically horizontal.

The outcrop from which a small quantity of coal has been

extracted, and which has been referred to by several travellers, is situated six and a half miles eastward from the Blackfoot Agency buildings, on a coulée which runs northward to the Bow. The deposit here consists of two seams, the upper averaging one foot eight inches in thickness, the lower three feet. They are separated by about a foot of carbonaceous shale. At this spot the bed may be traced about 500 feet in natural exposures, and is affected by variable dips which do not exceed 5° in amount. The thickness of the seams continues nearly uniform, and they would afford, say, four feet six inches of clean coal, the whole of which would be worked at once. The immediate banks of the coulée are about 80 feet high at this place, the upper two-thirds being composed of drift deposits, which rest on a worn undulating surface of the rocks below. The general level of the surrounding prairie is about 110 feet above the horizon of the coal, and no exposures of the coal or associated rock are found except in the river banks or coulées, which cut deeply into the surface of the plain.

In following the coulée northward from the spot just described, the coal is frequently seen on the right or east bank for about a mile, after which the coulée opens into a wider valley with sloping grassy sides, and exposures cease. Owing to the slope of the bottom of the coulée towards the river, the beds are cut into more deeply near its mouth, and at the last exposure the seam is about thirty feet up in the bank. The upper seam is here not well shown, but the lower exhibits a few inches over four feet of good coal. In an exposure intermediate between this and the first, the upper seam is eight inches thick, the shales one foot, and the lower seam four feet four inches. The seams are underlain by at least twenty feet of soft whitish sandstone. The same bed appears near the Agency buildings, where the Indian trail going eastward, leaves the valley, but the coal seams are here wanting or very poor.

Between the Blackfoot Crossing and the coulée above described, the same coal-bearing horizon appears in several places in the banks of Bow River. The seams are here more favorably situated for working, and of greater thickness than in the coulée. The subjoined section shows their mode of occurrence at one point:—

	ft.	in.
Coal	1	8
Black carbonaceous shale	1	4
Coal	1	8
Shale	0	3
Coal	0	9
Shale	0	3
Coal	3	0
Shale	1	0
Coal	1	10
Total	11	10
Total coal	8	11

The coal is here again underlaid by whitish sandstone for about thirty feet, or to the water's edge. Nearly opposite the exposure, on the south side of the river, the seam appears at intervals in the bank, at a height of about forty feet above the water, for at least a quarter of a mile. It is affected by a series of light undulations.

The natural exposures serve to prove the continuity in good workable thickness of the coal deposit over a tract of country several miles in extent, and its nearly horizontal attitude and moderate depth below the surface of the plains, would enable it to be proved by boring at a small expense over any desired area.

In texture, this coal is not so firm or well adapted for transport as those of the localities previously described, but in composition appears closely to resemble that of Horse-shoe bend.

The following are analysis of the fuel from this place; the first from a specimen obtained by Prof. Macoun, the second from one collected by myself, and probably not subjected to such prolonged desiccation:—

	I.*	II.
Water	10.72	13.20
Volatile combustible matter	29.26	33.80
Fixed carbon	46.09	48.10
Ash	13.93	4.90
	100.00	100.00

Three coal bearing localities on the head waters of the Oldman River appear to be of sufficient importance to obtain notice at the present time, but as the country toward the base of the

* By Mr. C. Hoffmann. Report of Progress, 1879–80, p. 12 H.

mountains becomes more fully known, it is probable that numerous additional outcrops will be discovered.

At the Government Indian Farm, south of Pincher Creek, a seam of coal occurs about one mile from the farm buildings up the valley of the small stream on which they are situated. The rocks in the lower part of the valley belong to the St. Mary River subdivision ef the Laramie, and dip toward the north-north-east (mag.) Their angle gradually increases from about 20° till the beds become nearly vertical where the coal occurs. Beyond this point the rocks are concealed, but the coal very probably occupies a position very near the base of the Laramie.

Near the coal seam, the beds have been much disturbed, and the coal itself is slickensided and broken throughout in such a way as to cause it to crumble easily by handling. The seam is two feet in thickness where exposed, but it is said to have been considerably thicker whêre followed into the bank. The opening made on the coal has, however, since been filled in. This seam should reappear on Pincher Creek, above the crossing place of the road, but the horizon at which it should occur appears to be covered.

An analysis of the coal from this seam by Mr. Hoffmann is given in the Report of Progress for 1878–79. p. 12 H. It may be quoted here for comparison with those of the other seams, and illustrates the improvement in quality of the coals on their approach to the base of the mountains:—

Water	6·26
Volatile combustible matter	29·31
Fixed carbon	55·70
Ash	8·73
	100·00

On the middle fork of the Oldman River, a few miles below the falls, and nearly north of the mill on Mill Creek, two miles of good coal occur in a scarped bank on the north side of the stream The beds are each about three feet in thickness, and are folded in a very remarkable manner, illustrating the intensity of the force which has acted in crumpling the rocks near the base of the mountain. It is probable that these beds occupy a horizon near the base of the Laramie. They approximate in character to true bituminous coals, and would yield coherent cokes, but no analysis has yet been made of them.

The section in which these coal seams occur is as follows. The order appears to be descending, but the whole may not improbably be overturned:—

	ft.	in.
Grey to black, very fine shale, with occasional small fish scales and bones, becoming sandy and yellowish at base	6	0
Ferruginous sandstone	0	6
Greyish, soft sandstone or arenaceous clay, with some thin ironstone layers	10	0
Harder greyish and ferruginous sandstone, with some obscure plant fragments	6	0
Hard, flaggy, yellowish sandstone	2	0
Grey sandy shale and shaly sandstone	3	0
Coal	3	0
Soft black carbonaceous shale	0	9
Grey sandy shale	3	6
Grey sandy shale and sandstone	4	6
Grey flaggy sandstone, weathering rusty	2	6
Grey sandy shale and shaly sandstone	5	0
Coal. Imperfectly seen, but at least three feet of good quality	3	6
Carbonaceous shale	1	0
Grey sandy shale	4	0
Ferruginous sandstone	0	6
Greenish-grey sandstone	10	0
Grey and blackish carbonaceous shale	4	0
Greenish grey, soft sandstone	6	0
Sandstone with arenaceous and carbonaceous shale, and general greenish-grey tints, (about)	80	0
	155	9

On Mill Creek, about four miles above the mill, a seam of coal outcrops. The measures are somewhat broken, and the seam appears to be rather inconstant in thickness. It was intended last autumn to make a careful examination of this neighborhood, and to endeavour to follow the coal-bearing horizon southward and north-ward from Mill Creek to its outcrop on other streams, but this was prevented by the the early onset of wintry weather. The coal is of excellent quality, and yields a firm coke. It has been used to a small extent in blacksmith-work at the mill. The following are sections of the seam on opposite sides of a break or fault which traverses the measures at the outcrop:—

	ft.	in.
Coal (rather shaly)	3	1
Coal	2	0
Shale	1	4
Coal	2	0
Shale	1	4
Coal	2	0
Total coal	9	1

	ft.	in.
Coal (rather shaly)	2	0
Shale	1	0
Coal (apparently good throughout, with the exception of a few shaly partings, not equalling four inches in all)	6	0
Total coal	8	0

The geological horizon of the coal at Mill Creek has not been determined.

GENERAL REMARKS ON THE COALS AND LIGNITES.

Whether from an economic or purely scientific point of view, one of the most interesting results of the exploration of the Bow and Belly River country is the determination of the fact that the coals are not confined to a single horizon and formation, but characterize at least four zones in the geological series of this region. The fuels found in the Laramie represent, at least in a general way, those characterizing the same formation or its representative, the Fort Union Group, eastward on the plains of the Souris River. As far north as the Athabasca and Peace Rivers, fuels are now known to occur in rocks of about the same age. The coal seam which has been referred to as attached to the summit of the Pierre shales, is not known to be represented elsewhere, unless indeed by a very thin seam near the same horizon on the Smoky River. (Report of Progress, 1878–89, p. 125 B).

The coal at the base of the Pierre, which has been worked at Coal Banks, on the Belly River, has not been recognized in a workable form beyond the limits of the district now described. The dark, highly carbonaceous beds at the base of the Upper Shales of Smoky River, are, however, at about this horizon, and in one place a thin seam of lignite coal is locally developed (op. cit. p. 118 B). A bed of lignite described by Prof. Cope on the

Missouri as in some places of possible economic value must also be of nearly the same age. (Bulletin U. S. Geol. & Geog. Survey, Vol. III., p. 566.) It is further worthy of remark that this coal-bearing horizon at the base of the Pierre of the interior continental region is, as nearly as possible, equivalent to that at the base of Chico Group, which yields the coals of Vancouver Island at Nanaimo and Comox.

The coal in the series below the Pierre on the Bow and Belly Rivers may be taken in a general way as representing those which occur in the Lower or Dunvegan Sandstones of the Pine River in the Peace River country (op. cit. p. 116 B).

The occurrence of workable coal seams at several different horizons, and the proved continuity of some of them over great areas, guarantees an abundant supply of fuel in this district, a matter of great importance in a country which over great areas is almost entirely destitute of wood. The quality of some of the fuels is such as to render them suitable for transport to a distance, and it is doubtless on this belt of coal-bearing rocks in the vicinity of the mountains that the railways of the North West will depend chiefly for their supply.

The quantity of coal already proved to exist is very great. The distances for which the outcrops of certain seams have been traced have been mentioned. Approximate estimates of the quantity of coal underlying a square mile of country in several localities have been made, with the following results:—

Main Seam in vicinity of Coal Banks, Belly River. Coal underlying one square mile, 5,500,000 tons.

Grassy Island, Bow River. (Continuation of Belly River Main Seam.) Coal underlying one square mile, over 5,000,000 tons.

Horse-shoe Bend, Bow River. Coal underlying one square mile, 4,000,000 tons.

Blackfoot Crossing. Workable coal in seam as exposed on Bow River. Underlying one square mile, 9,000,000 tons.

—*Report Geol. Survey of Canada,* 1882.

ON THE FORMER SOUTHWARD DISCHARGE OF LAKE WINNIPEG.

By J. D. Dana.

The most remarkable of the changes that are known to have occurred in the water-courses of North America is that in the discharge of Lake Winnipeg from a former southward course by the Minnesota Channel and Mississippi to its modern discharge into Hudson's Bay, first announced and sustained by General G. K. Warren, in a report of 1867, published in a Report of the U. S. Engineers for the year 1868 (pp. 307-314), after levellings along these rivers, by order of the Government, in 1866 and 1867. The question was more fully illustrated by General Warren in "an Essay concerning important physical features exhibited in the Valley of the Minnesota River and upon their signification," submitted to the Chief of Engineers in 1874, and published in the Report for 1875 (pp. 385–402); and afterward, further discussed by him in his paper on the Bridging of the Upper Mississippi, in the Report for 1878 (pp. 909 to 926) with a reproduction of some of the maps of the essay of 1874.

In the first of his papers, that of January, 1867, General Warren, after mentioning the evidences that "Lake Winnipeg was once continuous southward over the central portion of the Red River of the North, and had its outlet down the Minnesota, and not down the Nelson to Hudson's Bay" (pp. 307), considers the origin of the former hydrographical conditions. He speaks of the possibility of an ice-barrier in the north in the Glacial era; but he sets this idea aside, and argues for an actual change of land-level, and makes the southward discharge to have ended in consequence of a depression of land to the south, accompanying (as added in his paper of 1875) a rise to the north; and instancing, as examples of a corresponding change of level, the former *southward* discharge of Michigan Lake through the Illinois River, and of Winnebago Lake through the Wisconsin River. A map of the large Winnipeg Lake—larger he observes than Lake Superior and Michigan together, and having the Saskatchewan River as the head stream—accompanied the written report sent to the Department, but it was not published. The same view is presented at more length in the paper of 1874 (Report for 1875), along with a wider discussion of the facts,

and a review of the writings of previous travellers who had recognised the lake-like features of the region.

The idea of the southward discharge of Lake Winnipeg was presented again in 1875 by Mr. George M. Dawson, in his excellent Report on the Geology of the region in the vicinity of the 49th Parallel, with a recognition of General Warren's paper, but with the statement that the inference was an independent one. In explanation, he says (pp. 253, 254) that "by the flow of a large volume of water in this direction, the excavation of the basins of the Winnipeg group of lakes and the great valley of the Red River itself can be explained; the river cutting downward and westward on the sloping surface of the Laurentian rocks at the expense of the Cretaceous strata and later of the limestones of the Devonian and Silurian; the blocking up of the southern exit and changed direction of flow being a phenomenon only similar to that which is known to have taken place with the great lakes of the St. Lawrence."

The ice-barrier hypothesis has been sustained, in place of that of a change of level, by Professor N. H. Winchell, in his Minnesota Report for 1877, who there observes, in his explanation, that the lake, having first appeared at the south or Minnesota end, "grew toward the north as fast as the retreating ice-sheet made way for it." In the Minnesota Report for 1879, the same view is urged, with more detail, by Mr. Warren Upham.

A decision between these two conflicting explanations is of great importance to a right understanding of Quaternary events as well as of fundamental principles in terrestrial dynamics; and I therefore review here the more prominent facts, taking them mostly from General Warren's papers and the Report of Mr. Dawson.

1. The Red River of the North, rising in Lake Traverse, flows northward along the west side of Minnesota for 225 miles, crosses then the 49th Parallel, and continues on the same course for 90 miles to Lake Winnipeg; the distance from Lake Traverse to Lake Winnipeg being 315 miles.

2. The Minnesota, rising to the westward of Lake Traverse, enters its valley within two miles of it and flows south, through Big Stone Lake, to the Mississippi at Minneapolis.

3. The Valley of Red River, after narrowing much, is still 46 miles wide on the 49th parallel, and, for a long distance south

of the parallel, it has an average width of 30 miles (General Warren's map and G. M. Dawson's statement); toward Lake Traverse it narrows rapidly, is a mile long along the lake, the sides rising abruptly from the borders of the lake; beyond this lake, southward, it continues on, one to two miles wide, as the valley of the Minnesota River; and, where it joins the Mississippi, the valley has four times the width of the Mississippi valley above the junction (General Warren).

4. All now agree that the wide part of the valley which stretches northward from Lake Traverse is lake-bottom prairie, that it was adopted by the Red River, not made by it (Dawson); and that the part south of this lake is, as General Warren first showed, the deserted highway of the overflowing river and lake.

5. The Red River lake-bottom valley is bordered much of the way by abrupt sides rising 100 to 200 feet to the top of a terrace-plain or plateau; and, similiarly, the Minnesota channel has sides usually 100 to 150 feet in height.

6. Heights above the sea-level:

(B. C. means Boundary Commission Report.)

	1. Lake-bottom, prairie.	2. Bordering plateau.
Near 45° 30′ N., between Big Stone Lake and Lake Traverse (5 miles apart)........................	970	1,120
Near 47° N., at Fargo and Moorhead	900	1,050 (?)
On the 49th parallel near Pembina and St Vincent,*..............	784 (B.C.)	East side 989 West side 994
Toward Lake Winnipeg..........	740	810
Height of Lake Winnipeg (about the mouth of Red River, a great marsh) 710 feet		

* The height of the Lake of the Woods is 1048 feet (B.C.); of the divide between it and the near-by head of Rosseau River, a westward-flowing tributary of Red River along the 49th parallel region about 1078 feet (Dawson); edge of the plateau where it looks down on the lake-bottom about Pembina, 90 feet less (B.C.), and hence about 988 feet; Pembina Mountain, on the west side, 210 feet above the lake-bottom prairie, and hence 784+210=994 feet above the sea-level. Red River as it flows in its channel is 20 to 60 feet below the surface of the lake-bottom prairie; at Pembina, about 50 feet (Warren).

The heights on Minnesota River are (Winchell's Report):

Surface of bordering plateau near Big Stone Lake	1,125
At Mankato, 145 miles south	975
At Shakopee, 50 miles northeast	925
At junction with the Mississippi	800 to 820

7. The *slope* of the lake-bottom prairie is *northward*, toward Lake Winnipeg; and, from the 49th parallel, according to Dawson, it is nearly six inches per mile; the mean slope from Moorhead in Minnesota, 150 miles south of the 49th parallel, is little less than one foot per mile.

The slope of the bordering plateau *northward* from Lake Traverse to Lake Winnipeg, 315 miles, is about one foot per mile; for 1,125–810=315.

The slope of the bordering plateau along the Minnesota from Big Stone Lake to Mankato (145 m.) is *southward* and about one foot per mile; for 1,125–975=150.

8. The material of the lake-bottom, where examined by Mr. Dawson, is mostly yellowish clayey earth or lœss, containing calcareous matter enough to effervesce freely with acids; the upper portion is rarely so coarse as to be called sand, though sometimes an arenaceous clayey material; that of the border is also somewhat arenaceous. The depth of this lake-bottom deposit is generally 40 feet or more over the central portions, but it thins towards the sides. This point is illustrated in the plate facing p. 248 in Dawson's Report. He represents the lœss as overlying stratified drift and boulder clay. The surface of the prairie rises somewhat toward the sides; but whether the depression is more than would result from the drying (and consequent contraction) of so much wet loam after the disappearance of the lake, is not ascertained. It is rare to find anything like pebbly areas or pebbles over it.

9. The outline of the lake-bottom prairie has the appearance of being, so far as it extends, the outline of the great Winnipeg Lake, and is so recognized by Warren, Dawson and others.

10. The material of the bordering high plateau along both the Red River portion and the Minnesota is coarse gravel and sand; much of it unstratified till, much, more or less stratified; and the upper surface is often pebbly or stony, with occasional boulders.

Roseau River, for 25 miles east of the western edge of the plateau, says Dawson (p. 214), has cut deeply into the plateau

3rd.—The plant No. II., which was placed in the most favorable position as regards sunshine and rain, absorbed a greater amount of soluble iron and soluble phosphoric acid than plant No. III., which was grown in a less favorable position. Whether the plants have the power of selecting and taking up by their rootlets these compounds from the manured soil, or whether the plants simply absorb any substance in solution supplied to them, I am unable to say; but it appears that the healthy condition and gigantic growth of the plants Nos. II. and III. were due to the fact that they were supplied with iron (in a soluble form, $FeSO_4$) and phosphoric acid also in a soluble form.

I am inclined to think that a fairly large proportion of soluble iron and soluble phosphates in a soil is favorable to the growth of plants of a deep green color (that is, plants which develop a large amount of chlorophyll cells), like the varieties of cabbage.

From the researches conducted by Mr. F. C. Phillips, of the United States, "On the Absorption of Metallic Oxides by Plants" (CHEMICAL NEWS, vol. xlvi., 224), it seems that his experiments confirm the non-discriminating theory of plant absorption of Dr. Freytag.

Pnblished March 8, 1883.

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

THE REV. JAMES SOMERVILLE, FOUNDER OF THE SOMERVILLE LECTURES.*

By Rev. Robert Campbell, M.A.,

A formal memoir of Mr. Somerville was drawn up by his life-long friend, Dr. Daniel Wilkie, Rector of the High School of Quebec, in 1844, seven years after his death; while a shorter sketch appeared in the "Montreal Transcript," of the 8th of June, 1837, immediately after his decease, written by Mr. Thomas Blackwood, a prominent member of the Scotch Church.

Mr. Somerville came to Canada when only 27 years of age. and for thirty-four years he was minister of the Scotch Church in St. Gabriel Street; although for the last fourteen years of his life his connection with the Church was only nominal. Having been furnished with two colleagues, Rev. Henry Esson, in 1819, and Rev. Edward Black, in 1823, he withdrew from the active duties of the pastorate, on a retiring salary of £150, together with the £50, at that time given by the Imperial Government to ministers of the Scotch Church, in the Province of Lower Canada. He was ordained and inducted into office in 1803, by Dr. Sparks, of Quebec, and Mr. Bethune, of

* The Rev. Mr. Somerville bequeathed to the Natural History Society of Montreal the sum of £1000 to maintain an annual course of Lectures in connection with the Society, to be known as the Somerville Lectures. Rev. Robert Campbell, one of the Somerville lecturers for the present year, discoursed on the life and bequests of Mr. Somerville. We print this extract from his lecture, feeling that a sketch ot Mr. Somerville's life should be placed on record in the Journal of the Society, for which he did so much.

Cornwall, father of the late Dean of Montreal, the only other Scotch ministers at that time in these inland Provinces. He took a leading part in all movements for promoting a wholesome state of society. To this end he connected himself with various organizations, the Freemasons among the rest. His, too, was the first name on the roll of the Montreal Curling Club, organized in 1807. In 1809 he succeeded in establishing a literary society, having its headquarters in this city. Dr. Wilkie will tell us its history. "He coveted the society of well-informed persons, and the free communication of ideas. Hence sprung up in his thoughts the conception of the Symmathetical Society, formed for the purpose of promoting mutual improvement, and possibly to be the germ of some greater association. He laid hold of the thought with eagerness and communicated it to a very few gentlemen, in whom he had confidence, in Montreal, and to one or two residing at a distance. The proposal was zealously embraced by the few friends to whom it was explained, and carried out with considerable regularity for a few years. A number of essays were furnished from time to time by each of the gentlemen associated, and these were pretty fully discussed at the meetings of the society. Remarks were likewise communicated in writing, and a regular account of all the transactions recorded by one of the members, appointed to act as secretary. A few of these papers were afterwards printed in the "Canada Review," in 1824. The subjects discussed were chiefly scientific, literary or commercial." His biographer tells us:—"During his whole life he was wont, when his health permitted, to take daily exercise in the open air. . . . In his rambles he used to carry a small hammer, with which he amused himself in examining the interior appearance of stones and rocks. If this was not done in a strictly scientific manner, it served at least to diversify his recreations and give them activity. Sometimes he collected plants and flowers, and he had ever a just appreciation of the beauties of natural scenery." "Sometimes he was joined" in his rambles "by one or more of his clerical brethren, who, it is well known, were always attracted by his lively conversation." He kept a diary from the time he was 22 years of age, and in it he made notes especially of the state of the weather, to the influences of which his frame was keenly susceptible. This record he kept up till within 48 days of his death. It was probably not very scientific, as he is not

likely to have possessed very accurate instruments; but such as it was, in the absence of any better statistics of temperature and other elements affecting the weather, it would be at least curious, if not very valuable, could it only be discovered; but after full inquiry I have been unable to ascertain what has been the fate of this journal.

When he died, in 1837, he left the most of his property to religious and benevolent institutions. I will let Dr. Wilkie tell how he was led to do so:—"It has been seen throughout the course of this narrative that his mind was eminently sociable. Being at the same time of a strongly benevolent cast, his sociability gave rise finally, or at least greatly contributed, to two most excellent institutions—the Natural History Society and the Montreal General Hospital. His practice of rambling in the fields in quest of objects suitable for the study of natural history has been already noticed. His attractive conversation naturally drew to his society others who possessed similar tastes, particularly his two brethren in the church, and some of other professions. One gentleman especially, of highly scientific attainments, supposed to be A. Skakel, a teacher in this city, assisted to give accuracy and order to their observations. A considerable collection of natural objects was, in consequence, formed; a place was found necessary for their reception, the assistance of others was solicited and obtained, and out of these humble endeavours arose 'The Natural History Society' of Montreal."

In consequence probably of his connection with the origin of this institution, and certainly from his devotedness to the cause of knowledge and truth, he left a munificent bequest for the endowment of a lectureship in furtherance of its objects.

His sympathetic nature and public spirit seem to have had much to do also with originating the Montreal General Hospital. Here is what the memoir says on this point:—"He always considered the first suggestion of the Montreal General Hospital as due to himself. "The first idea of it," he said, "was suggested by his servant falling sick of an infectious fever. She had no friends in the city. He could not turn her out of doors. He was apprehensive for his own family. He thought how advantageous it would be for the patient, how satisfactory to his own mind, if there was an hospital to which she could be sent, where she would receive the necessary attention and care, while his family would run no risk of infection. Others might be in

similar circumstances. He proposed the subject to some medical gentlemen, and also to his colleague, who always had been forward to promote objects of public utility. The scheme was followed up with zeal and liberality. An institution arose far surpassing his utmost expectation." "Such," in the words of an intimate friend, with whom he often conversed, "was the development in his truly Christian mind of an institution which has since grown to be one of the honors of Canada—an institution of which Montreal will always be proud, and to which the late Hon. Mr. Richardson, after all highly valued labours, had the honour of making an important addition."

By his will, drawn up on the 21st of February, 1833, four years before his death, "he left bequests in the following order, and to the following amount:—For the purchase of a ground lot and erection of a manse, for the use of the minister of St. Gabriel Street Church, during thirty years the object of his warm and constant solicitude, £1000; to support a lectureship for the benefit of the Natural History Society of Montreal, £1000; to Mr. David Wilkie, at Quebec, his friend from early life, £1000; to the Rev. Alex. Mathieson, of Montreal, many years an intimate friend, £100; to the late Thos. Blackwood, Esq., one of his oldest and most confidential friends at Montreal, £100; and to the Trustees of the Montreal General Hospital, as residuary legatees, all that might remain after paying off all the above mentioned legacies." Dr. Wilkie remarks: "The remainder falling to the General Hospital must, it is believed, be very considerable, and will, no doubt, be suitably recorded."

In our time the amounts bequeathed by Mr. Somerville to public objects, do not seem large; but fifty years ago they must have been counted considerable, when there was comparatively little realized wealth in this country, and money was so much more valuable relatively, than it is now. Though not looking very large to the present generation, they were timely; and the several sums applied to the respective objects contemplated in his final benevolent disposal of his means were productive of more important and lasting results to those public objects than five times the amount would be to-day. His thoughtful generosity put the institutions which it aided on a prosperous footing, and once they got fairly under weigh, their success became assured.

It was not from his professional income, however, that the

money came which he had at last to leave. It was in the first instance a gift to his son and daughter by a female friend, prompted no doubt out of respect and affection for himself; and then when they were taken from him suddenly, and he became entitled to spend it in any way he pleased, he held it as consecrated by the hallowed memories of his departed children, not to be expended on personal gratification but to be a lasting monument of the loved ones through whose untimely decease it came into his hands and under his sole control.

Such was the man and such was the work he achieved, and I think your verdict will coincide with mine that he deserves to be remembered by the citizens of Montreal. I do not claim that he was a man of brilliant intellect or of surpassing powers in any way; yet his character and attainments were of a kind to maintain the credit of the order to which he belonged, and to exercise a very widespread and wholesome influence over the English-speaking society of this city, when it was a community so small that every clergyman had a personal acquaintance with its members.

But to the members of this society that which appeals on behalf of Mr. Somerville's memory with most effect, is the fact that the society itself owes its origin to his enthusiasm for natural science, and that this building which is associated with the memory of so many delightful scientific reunions was erected partly by means of the legacy which he bequeathed to the society. In what ways it has helped forward the objects of the society you all know far better than I; and it remains for others having means at their disposal, as you suggested, Mr. President, to complete the work begun by Mr. Somerville, by further endowing the society, and so setting the foundation free for the enc uragement of original research in natural science, the results to be communicated to the public in the Somerville Lectures.

No word of mine is needed to set forth the benefits accruing not to Montreal alone, but to the whole of Eastern Canada from the establishment of the General Hospital. There is no public institution which has stronger claims upon the consideration of the people of Montreal, or for the existence of which they ought to be more grateful. It has profited by the generosity of many citizens since, 1837; and it is still receiving well deserved aid from bequests, probably much larger than that left by Mr. Somerville; yet, if what I have asserted as to his early rela-

tion to the institution, be granted, it owes more to him than to any of its benefactors.

And yet the remains of this man who did so much to mould the early history of Montreal, when its society was still plastic, planting the seeds of goodwill and honor and truth in its virgin soil, and who also is entitled to the credit of originating two of the most prominent and useful institutions in the city, lie to-day in a nameless grave in Mount Royal Cemetery. They were first deposited alongside those of the members of his family, who all died before him, in the Protestant Burying Ground, on Dorchester Street. His friend, Dr. Wilkie, to whom, as has been seen, he left a handsome legacy, erected a very tasteful monument to his memory. But when the authorities of the city resolved to convert the old place of burial into Dufferin Square, a proceeding against which a good many minds revolted, no delicacy of sentiment was shown in carrying the resolution into effect; and in the general demolition of monuments which followed, the beautiful memorial which Dr. Wilkie's friendship had dedicated to Mr. Somerville's memory was so injured before the attention of any person interested in its preservation was called to the matter, that it could not be re-erected except at a cost such as would almost suffice to replace it with a new one. As St. Gabriel Church profited by Mr. Somerville's generosity, I felt called upon, in the absence of any kindred of his left in the country, to take action and have his remains removed to Mount Royal Cemetery. A few members of St. Gabriel congregation subscribed about $100, and a very eligible lot was procured in a prominent position, and there, we trust, his bones will lie undisturbed until the resurrection. But, while there are on all hands granite and marble monuments over the graves of citizens of less account, is it fitting that the last resting place of one who so well deserved to be remembered by the community, should be unmarked by so much as a marble slab? It may be said that he has erected his own monument, one more lasting than brass, in the bequest that he made to this society, the benefits of which to the citizens have been pointed out; and in the still more distinguished public charity, the General Hospital, the foundations of which he helped to lay. But that he did his duty does not release us of the obligation of doing ours. The citizens of Montreal are not likely to be ungrateful. They will not forget their benefactors. The people of St. Gabriel Church have already done a share of the

work—the appointment of Mr. Marler, the Treasurer of the Natural History Society, at the meeting on Monday night, to co-operate in any effort to be made to finish the work, gives promise that, so far as this institution is concerned, the members of it will do what is right in the matter. And now it remains for the authorities of the General Hospital to take action. The President has expressed sympathy with the movement, and has requested me to furnish him with a memorandum, setting forth the facts and requirements of the case, and he will bring the subject before the Board of Management. If they will appoint a representative, and St. Gabriel Church a third, to form with Mr. Marler a committee to take this matter in hand and carry it to completion, the end may be regarded as good as accomplished. Of course none of these religious or benevolent societies can be expected to vote any money from their respective treasuries, but if the influential gentlemen entrusted with their management will only show a deep interest in the matter and will commend it to the friends of the several institutions, I apprehend there will be no difficulty in procuring two or three hundred dollars with which to erect a simple monument over Mr. Somerville's grave.

NOTES ON CANADIAN EARTHQUAKES.

By Prof. C. G. Rockwood, Jr., Ph.,D., Princeton, N. J.

The following notices of earthquake shocks felt in Canada since 1876, are gathered here, from the authors "Notes on American Earthquakes," published at various times in the "American Journal of Science and Arts."

1877.

May 2.—A shock, "lasting eight or ten seconds," occurred at 10.20 p.m., at Oshawa, Ontario.

May 15.—From Port Stanley, Ontario, it was reported that a wave five feet high, apparently due to some earthquake shock, swept along the northern shore of Lake Erie, and was followed for an hour by smaller ones.

July 17.—At 3 a.m., a sharp shock, lasting about thirty seconds, occurred at Rivière du Loup, Quebec.

Nov. 4.—About 2 a.m. a rather severe earthquake was felt throughout a large part of Canada, New York and New England.

It was reported from Ottawa, Perth and many other places in Ontario, east of a line joining Kingston and Pembroke; from Cornwall, Montreal and other places in the St. Lawrence Valley, as far east as Three Rivers; from Hanover, N. H., Springfield, Mass., Hartford, Conn., and other places along the Connecticut River; from Burlington and Bennington, Vt.; from Plattsburg, Whitehall, Saratoga, and the valley of Lake Champlain and the Hudson, as far south as Albany, N. Y.; and finally from Utica, Rome, Auburn and the Mohawk Valley. It would thus seem to have been felt over an irregular trapezium, whose angles are marked by Pembroke, Ont., Three Rivers, Que., Hartford, Conn., and Auburn, N. Y.; and which is therefore some 200 miles on its northern and southern sides, about 300 on the east and 175 on the west. Comparing the reports of time from thirty-six localities, we find them cluster closely about 2 a.m., none earlier than 1.45, none later than 2.10—most being between 1.50 and 2, local time. The most accurate appear to be Montreal, 1.50 a.m., Hartford, 1.56=1.52, Montreal time, and Dudley Observatory, Albany, 1.53=1.54, Montreal time. The duration in Montreal was about twenty seconds, and in other places about the same. It seems to have been most severe in the valley of the St. Lawrence and about Lake Champlain, where the vibration was sufficient to overturn crockery, crack ceilings, and, in a few cases, throw down chimneys. The reports were nearly unanimous that the vibration advanced from west to east. In some places a rumbling noise, and in others two or several shocks were reported.

Nov. 14.—At 9.40 a.m. a slight shock occurred at Cornwall, Ont.

Dec. 18.—At Beachburg, Ont., two shocks occurred, the first between 1 and 2 a.m., the second between 5 and 6 a.m., and quite severe.

1879.

June 11, 12.—A light shock at 10 p.m. was felt at Montreal and east and southeast from there, as far as Waterloo and Frelighsburg. At Montreal it was described as "loud rumbling, slight shock and continuation of rumbling." The direction was said to be N. to S. Some persons reported a second light shock and rumbling at 2 a.m. on the 12th.

Aug. 21.—The country between Lakes Erie and Ontario was severely shaken about 3 a.m. The earthquake was reported from

Buffalo, Lockport, and Niagara on the New York side, and from various places as far west as Beamsville and Welland on the Canada side. At most places an explosion was heard and at St. Catherines the shock was strong enough to cause the church bell to make two taps.

1880.

Feb. 8.—Between 8 and 9 p.m. a slight shock was felt near Ottawa.

April 3.—At 10 p.m. a slight shock was felt at Quebec and Ottawa.

July 22.—At 2 a.m. a shock was felt at Ottawa, from west to east, with rumbling noise.

Sept. 6.—A slight shock occurred a little after midnight at Montreal, Huntingdon and Cornwall. The time given at Huntingdon was 0.30 a.m.; at Cornwall, 2 a.m.

Nov. 6.—Under this date the Princeton (N. J.) Press reported, "A shock of earthquake has been felt at Newcastle, Ont." No other account of it has come to hand, and it is regarded as doubtful.

Nov. 24.—At 11.45 p.m. a shock occurred at Quebec.

Nov. 28.—At 8.30 a.m. a shock occurred at St. Paul's Bay.

1881.

April 7.—At midnight, on the morning of the 7th, a shock was felt at St. Paul's Bay.

May 31.—At 3.20 a.m. a heavy shock occurred at Murray Bay and vicinity.

June 19.—In the morning a slight shock was felt at Ottawa.

Oct. 1.—At 1.40 a.m. a strong shock occurred at Kamouraska, Quebec. It may be remarked that twice before during the year (April 7 and May 31), this same vicinity had been shaken.

Dec. 4.—At 6.30 p.m. a slight shock occurred at Huntingdon; direction, west-east.

1882.

Feb. 26.—At 6.25 p.m. a shock lasting three or four seconds occurred at Murray Bay.

Aug. 1.—At 6 p.m. a light earthquake was felt at Point des Monts, Quebec.

Aug. 15.—At 10.30 a.m. a strong earthquake was felt at Point des Monts.

Sept. 20.—At noon another light shock occurred at Point des Monts.

Oct. 10.—At 4.15 a.m. a slight shock occurred at Montreal, felt also at Lachine, St. Hilaire, Huntingdon (5 a.m.), and other places in that vicinity.

Nov. 27.—At 6.30 p.m. a severe shock occurred at Welland, Allanburg, Port Colborne and other places along the Welland Canal.

Dec. 31.—About 10.05 p.m. a decided shock with rumbling noise, was felt in Halifax, N. S., and other places along the railroad to Truro. It was felt generally in New Brunswick and was also reported from Eastport (9.55), Rockland (10 p.m.), and Bangor (9.30 p.m.) in Maine.

Princeton, N. J., March 13, 1883.

ON SOME RECENT ANALYSES OF SOILS.

By J. Baker Edwards, Ph.D., F.C.S., Public Analyst.

(Read before the Natural History Society, February, 1883.)

Having lately been called upon professionally to examine and give an opinion on several samples of soil very different in origin, in locality, and in composition, I thought it might be well to lay my results before the Society. The first was from a delta of the small river St. Pierre, running alongside of the ship canal between Lachine and the Tanneries. This soil is also evidently a former bed of the River St. Lawrence, and is rendered comparatively valueless by the large boulders left by the old ice current in the valley which the Lachine railway now traverses. It is now swampy land, having been banked out by the ship canal; but by the removal of these stones would become valuable market garden land, draining into the River St. Pierre. It is full of fresh water shells and of vegetable deposit, of a light and arable character, with enough sand to make good drainage, and with proper drainage into the river would prove a most fertile soil.

This soil yielded upon analysis as follows:—

Class 1.

Three samples soil of between Lachine Canal and River St. Pierre, gave.

1. Surface bog soil.

Water	30·0
Organic matter	10·0
Clay	6·0
Sand, gravel and shells	54·0
	100·0
Soluble in acid	8·5
" in water	5·0

No. 2. Detritus from the River St. Pierre—dried—consists chiefly of carbonate of lime, silicate of alumina, and about 5% organic matter.

No. 3. Three do. in banks—pure shell marl—containing fresh water shells and potash ashes.

Class 2.

SAMPLE OF SOIL FROM FERTILE ORANGE BELT OF FLORIDA.

This is a nearly pure chalk of marine origin, composed almost entirely of carbonate and silicate of lime, yielding

Carbonate of lime	90·0
Silicates of lime and potash	4·8
Silica	4·0
Organic matter containing traces of phosphates, alumina, iron and soluble salts (sodic)	1·2
	100·00

This chalk is evidently of marine origin and requires admixture with other materials to be generally fertile and cultivatible.

Class 3.

Analysis of three samples of soil from North-West Territory, Section 27, Township 11, Range 27 West of 1st Meridian, Manitoba. Taken 31st Oct., 1882, by McPherson Le Moyne, Esq.

No. 1. *Taken from surface of highest knoll*, contains :—

Moisture	4·6
Organic matter (containing nitrogen)	11·8
Carbonate of lime	30·0
Phosphate of lime	1·4
Salts soluble in water, largely potassic	8·6
Silica, silicates and gravel	43·6
	100·0

No. 2. Soil taken at 15 inches below the surface of the same knoll, contains:

Moisture	3·2
Organic matter	6·0
Lime as carbonate	51·4
" as phosphate	3·0
Salts soluble in water	4·6
Silica, silicates and gravel	31·8
	100·0

Sample No. 3. Soil taken from 24 inches below surface of same knoll, contains:—

Moisture	2·0
Organic matter	4·2
Carbonate of lime	24.0
Phosphate of lime	4·6
Salts, soluble	10·4
Silicates and gravel	54·8
	100·0

This shows a favorable condition of the subsoil in regard to phosphates, and the substratum being chiefly gravelly, is excellent for drainage.

These results must not be taken as of extreme accuracy—the ultimate and exact analysis of the elements of a soil being one of the most elaborate and tedious operations in chemistry, and Dr. Hunt has done good service to science in the publication of careful results of analysis of the soil and subsoils of the Champlain wheat-exhausted districts, once called the "Granary of New France." I have in the general outline followed his methods of analysis, but not to minutiæ, and perhaps he has not seen much reason to modify the opinion he expressed twenty years ago, in the Report of Geol. Survey of Canada for 1863, "that extremely "delicate chemical details would not afford reliable data for agri- "cultural guidance." The general nature of a soil and its subsoil, however, affords a glimpse of its possibilities which may be of great practical value to the cultivator.

NOTICE OF GRAPTOLITES OF THE QUEBEC GROUP COLLECTED BY MR. JAMES RICHARDSON FOR THE PETER REDPATH MUSEUM.

BY J. W DAWSON, LL.D., F.R.S.

As it seemed appropriate that a portion of the Logan Memorial Collection should consist of the fossils of Sir William's "Quebec Group," of which, after the removal of the Geological Survey, no adequate collections existed in Montreal, Mr. Richardson, late of the Geological Survey, kindly undertook to procure specimens for the Museum. Mr. Richardson visited for this purpose the rich graptolitic localities at Levis, and also a locality recently discovered by himself near Matane. The result has been the accumulation of a large collection, part of which is already arranged in the Museum.

In addition to the collection of specimens, Mr. Richardson's labors have given us some new facts respecting the graptolitic fauna of Canada, which may be noticed here in advance of more detailed study of the collections.

The original locality in the river cliffs at Levis, which afforded the greater part of the species described by Prof. Hall, in the decades of the Geological Survey of Canada, constitutes a distinct graptolitic zone extending for a considerable distance along the river front of Levis, and affording species of a number of genera, among which are present, though comparatively rare, *Phyllograptus*, *Didymograptus* and *Tetragraptus*.

Farther inland, near Fort No. 2, in beds of dolomitic shale, associated with limestone conglomerate, but whose precise stratigraphical relation to the shore beds has not yet been determined, Mr. Richardson has found a second zone crowded with *Phyllograptus typus*, mostly of the narrower variety, and abounding in specimens of *Tetragraptus bryonoides* and more rarely *T. Bigsbii*. These beds also hold a *Dictyonêma* of the type of *D. Sociale*, but distinct.* There seems good reasons to believe that these

* This species has been named *D. delicatulum*, and may be thus described:—General form funnel-shaped in small specimens, apparently flabellate in old specimens. Length of a large specimen ten centimetres, breadth at top about the same. Texture very delicate, the

fossils indicate a second graptolitic zone, possibly older than that which afforded the species described by Hall.

At Matane Mr. Richardson has found a bed of highly laminated black shale similar to that explored by Mr. Weston a few years ago at Little White River, holding similar fossils in great abundance. Prominent among them is a beautiful *Dictyonema*, distinct from any of these found at Levis, and which on comparison with specimens presented to the Museum by Prof. H. Alleyne Nicholson, appears so close in all its characters to *D. sociale* Salter, of the English Tremadoc, that it may fairly be assumed to represent that species in our fauna. It is well known that some good palæontologists regard *D. sociale* as only varietally distinct from *D. flabelliforme* of Eichwald from Russia; and the Norwegian species known as *D. Norvegicum* and *D. graptolithinum* are also regarded as varieties of the same species, which in all these countries seems characteristic of the upper Cambrian beds.* We might infer from this that the *Dictyonema* beds at Matane may indicate a horizon somewhat lower than any of those at Levis. Associated with the *Dictyonema* are many specimens of *Didymograptus flexilis* and *D. Logani*, or an allied form, and there are also fragments of an undetermined *Tetragraptus*. In a neighbouring bed there is a vast quantity of *débris* of Trilobites, and though these are all in a very fragmentary state, yet such specimens as give any indications of the genera to which they belong, would seem to agree with the graptolites in indicating an Upper Cambrian age. They are apparently more nearly related to the trilobitic fauna of the Potsdam of Newfoundland, as described by Billings, than to that of Levis.

It is no doubt true that organisms like graptolites, which have a great range both in time and space, are not so much to be relied on as some other fossils in determining subdivisions of formations. Yet there seems reason to believe from Mr. Richardson's recent observations that graptolitic zones reaching from the Lower Tremadoc to the Upper Llandeilo may be discriminated in the great mass of sediments known as the "Quebec Group," which

---

vertical stems being slender and as many as 18 in a centimetre. Cells in one series, round in cross section; aperture pointed, but apparently not mucronate; transverse bars very slender, more distant than the vertical stems but constituting a distinct network.

* Dr. Schmidt in Journal of Geological Society of London, Nov., 1882.

the writer has long believed, on the evidence of the fossils he has himself observed, to represent a lapse of geological time extending from the base of the Potsdam to the Chazy limestone.†

Specimens of Mr. Richardson's graptolites have been sent to the Geological Survey Museum, and will also be sent to the State Museum at Albany, and it may be hoped that they will be studied in more detail by the palaeontologists of the Canadian and New York Surveys.

THE PROBOSCIS AND BLOOD-SUCKING APPARATUS OF THE MOSQUITO, GENUS *CULEX*.

By Fdward Murphy, Esq.

(Read before the Natural History Society, 30th April, 1883.)

It is an interesting question how a creature as small as the mosquito, and so very light that the slightest breeze will blow it away, can hold on to its prey with sufficient tenacity to force through a hard epidermis, and into the solid flesh, the very delicate and perfect instruments with which nature has furnished it for feeding.

The object of this paper is to lay before the members of the Natural History Society the result of repeated observations made on the mosquito while feeding, and a careful examination of its organs under the microscope. Having dissected a number of these little creatures I can with some confidence submit the following results of my observations, taken from notes made on these insects, and shall illustrate the subject by mounted specimens prepared by myself, now under the microscopes for examination.

Entomology teaches that in the "blood-sucking" insects there is a wonderful modification of the mandibulate mouth.

In the mosquito a prolongation of the *labium* forms a fleshy proboscis, covered with minute scales, having a muscular contraction a short distance from the point or end, which not only holds the sucking tube, the saws and other feeding organs in a compact body for insertion when required, but probably also forms a cleaning organ, through which they can be drawn.

---

† See also Dr. Selwyn's remarks on this subject in the Report of the Geological Survey, 1877-78, pp. 4-5.

When the instruments are inserted into the flesh, the proboscis is pushed back at an angle more or less acute, and having somewhat the appearance of a leg with a bent joint.

The mandibles have been modified into a pair of extremely small and beautiful saws, whose sharp teeth, generally *ten* or *twelve* in number, occupy about one-twelfth to one-fifteenth of the length of the proboscis, the teeth are small at the point of the instrument but they increase in size to about the middle of the saw, and being *set backwards*, they not only act as cutting tools, but from their barbed shape, give the creature the "purchase" necessary to hold it to its prey.

A careful observation of the insect, while feeding, shows it *pulling* the saw on one side, as it *pushes in* the saw on the opposite side. *The saw that it pulls is the saw that cuts;* thus the action that increases the depth and size of the wound also gives the creature the necessary "purchase" to enable it to push in the opposite saw.

Between these saws and the tube or sucker, the *maxillae* are modified into a pair of irritators (these are horny and stiff like bristles) supposed to be used to excite and increase the flow of blood, and possibly used also to prevent any solid matter entering the tube in drawing or sucking up the blood.

The sucking tube is a modification of the tongue, is horny in structure, sharp pointed and *solid at the end*, so that it may be pressed firmly against the bottom of the wound without the risk of being stopped up, as it might be if the orifice was at the end, the blood flowing through a hole like the eye of a needle, which opens into the tube at a distance from the point equal to about the diameter of the tube.

In conclusion, I have only to add that in the feeding apparatus of the mosquito, we have a beautiful illustration of a perfect and wonderful adaptation of means to ends.

THE HEAD AND SUCKING APPARATUS OF THE MOSQUITO.

BY WM. MUIR ESQ

(Read before the Natural History Society, April 30th, 1883.)

The Labrum, or upper lip or sting, composed of chitine or transparent horny substance, nearly cylindrical, slightly tapering and needle-pointed, is $\frac{1}{9}$ in. long and at $\frac{1}{100}$ in. from the tip is $\frac{1}{350}$ in. dia. at $\frac{1}{100}$ in. from the root is $\frac{1}{200}$ in. dia.

The Labium, under lip or sheath, composed of muscular substance united together in short sections, by which means it can be doubled up under the head when the piercing apparatus (which it encloses) enters the wound and plunges into the flesh, is provided with a strong muscular joint near the tip, which clasps the piercing apparatus and holds them in position while doing their work. The tip is composed of two parts which apparently open out and lie on the skin, while the creature is feeding.

The mandibles, of which there are two, are similar in form to a scythe blade, of the same length as the labrum, and at the back or thickest edge $\frac{1}{4000}$ in. dia. Attached to this structure, and running to near the point is an exceedingly thin striated membrane, the striae being $\frac{1}{5000}$ in. apart, and curved at the ends—the tip is sharp pointed and has six teeth turned inwards like a ripping saw—the upper tooth having a projection of $\frac{1}{5000}$ in., the others tapering to the end. The six teeth are in a space of $\frac{1}{450}$ in.; above these are seven bent hooks in a space of $\frac{1}{200}$ in.; in some specimens these latter are like the teeth of a reaping machine.

The maxillæ, of which there are two, are exceedingly thin transparent flat ribbon-like membranes, uniform width, slightly pointed—the edges at the point serrated—the length same as labrum, $\frac{1}{2000}$ in. broad and $\frac{1}{20,000}$ in. thick.

The analogue of the tongue, a small hollow tube $\frac{1}{8000}$ in. dia., pointed at the end, having a thin membrane on each side.

These five—the two mandibles, the two maxillæ and the analogue of the tongue—lie in the hollow of the cylinder composing the labrum, under it and next the labium.

The palpi are club-like, having a small knot at the ends, three jointed, covered with hairs. They are $\frac{1}{34}$ in. long, $\frac{1}{160}$ in. thick.

Antennæ, spring from a bulbous root, and are composed of 13 cylindrical joints, having each a whorl of five long hairs—the last joint tipped with a short point or finger; they are $\frac{1}{8}$ in. long, $\frac{1}{530}$ in. dia., slightly tapering.

Eye, compound flattened, hemispherical $\frac{1}{600}$ in. dia.

Head, $\frac{1}{25}$ in. dia., having an internal pear-shaped sack near posterior part and connected with the labrum.

Wings, $\frac{1}{7}$ in. long, $\frac{1}{16}$ in. broad—the membrane covered with short hairs $\frac{1}{1650}$ in. apart. The veins or ribs thinly covered with scales; the posterior edge and tip fringed with scales—shaped like a canoe paddle $\frac{1}{140}$ in. long, the neck $\frac{1}{7400}$ in. dia., the broadest part $\frac{1}{1500}$ in., and $\frac{1}{1250}$ in. apart—the neck cylindrical, the blade beautifully striated and in some cases pointed at the ends. Between these there is another row of the same description and form, only half the size.

The total length of the creature from the tip of the labrum to the end of the abdomen is $\frac{1}{3}$ inch.

NATURAL HISTORY SOCIETY PROCEEDINGS.

The fourth meeting of the session 1882–83, was held on the evening of February 26th—the President, Dr. Dawson, occupied the chair.

Messrs. Thomas Robin and Joseph Fortier were elected ordinary members.

Dr. Alloway exhibited samples of marble, mica and granite from the vicinity of Papineauville, County of Grenville.

Mr. Walter F. Ferrier then read his

"NOTES ON A FOSSIL TRACK FROM THE POTSDAM SANDSTONE OF NORTHERN NEW YORK STATE."

And exhibited the slabs upon which the impressions occur.

He said the specimen was found 60 feet from the east edge of the precipice, at Rainbow Falls, Ausable Chasm, Essex County, N. Y., in the cellar of the Ausable Chasm Horse Nail Works. It was quarried out of the rock about five feet below the surface bed. The beds in which it occurs are generally thin and dip to the S.E. at an angle of about 3° 30′. Ripple marks, very well preserved, are abundant in these beds and in some layers, an Ophileta (probably *O. compacta*, Salter) has been noticed, but

no *Lingulæ* or *Scolithus linearis* have been met with at that spot although they both occur in the vicinity. The sandstone is of a light brownish color and very hard and compact. The tracks were first noticed by James Ferrier, Jr., of Montreal.

Dr. Dawson said one of the tracks is a cast of two narrow furrows about a quarter of an inch apart, with a row of punctiform impressions about an inch distant at either side. This impression is repeated in two places on a ripple-marked slab. It may be the track of a Trilobite with two prominent spines on the pygidium, possibly of some species of Dikellocephalus. Another is a trail about an inch in width, marked with transverse furrows and ridges, perfectly simple, and without any median ridge. In this last respect they differ from the trails known as Rusichnites, Cruziana, Arthrichnites (Arthrophycus), and Fraena. They resemble, though on a larger scale, impressions from the Erian sandstone of Gaspé, (of which a slab from the McGill College collection was exhibited for comparison). Such impressions, destitute of a central ridge, may have been made by gasteropods or by worms without any abdominal furrow. These impressions belong to the genus *Gyrichnites* already proposed by Mr. J. F. Whiteaves, for the similar impressions from the Erian of Gaspé.

Mr. J. U. Baudry described a visit to the wonderful gorge and cave at Covey Hill, about twenty miles from Beauharnois.

Dr. J. Baker Edwards then read a paper on "Recent Analyses of Soils, which may be found at page 458.

The fifth meeting was held on March 26th—the President occupied the chair.

Messrs. R. C. Adams, P. J. N. Beaudry, of Beauharnois, and Arch. Wurtle, were elected members, and Messrs. W. H. Rintoul, and W. A. J. Bond, proposed for membership.

A letter from Mr. Geo. Whitfield, of Rougemont, was read inviting the Society to hold its field-day at his grounds.

Prof. Lockwood, of Princeton, N. J., presented a paper on "Canadian Earthquakes since 1876," which was read by Dr. T. Sterry Hunt. This paper is printed in full at pages 455–458.

Dr. Dawson then read the following biographical sketch of the late Mr. Barnston, a former president of the society, and a member of the Royal Society of Canada:—Mr. Barnston was of English parentage, but was born and educated in Edinburgh. It was apparently intended at one time that he should enter the

army, and he studied for that purpose, but he eventually joined the service of the Old North-West Company, leaving Scotland in 1820 for Canada. Shortly after this time a union of the Old North-West and Hudson's Bay Companies was formed, and Mr. Barnston continued with the new company, in which he remained for forty-one years. He was stationed in the course of that time at various points from the Gulf of St. Lawrence to British Columbia. He crossed the Rocky Mountains into British Columbia as early as 1825 or 1826, making the return journey in winter on snow-shoes. When in British Columbia he established the first factory on the Fraser River. When at York Factory in 1824 he assisted in fitting out Franklin's party, and at Norway House, thirty years later, he aided the expeditions under Rae and Anderson and Stewart. He married in 1830 Miss Matthews, daughter of Mr. W. Matthews, one of the pioneers with Jacob Astor. In 1867 he retired from the service of the Hudson's Bay Company and took up his residence in Montreal, where he died on the 14th March, 1883, in the 83rd year of his age. Mr. Barnston throughout his residence in the Hudson's Bay Territory was a diligent collector in botany and zoology, and contributed collections of insects, plants, &c., to the British Museum, the Natural History Society of Montreal, the McGill University and other institutions. In 1872–73 he was President of the Natural History Society. At Montreal he occupied himself with the determination and arrangement of the specimens he had collected, and prepared notices of them for publication, more especially in the *Canadian Naturalist*. The most important of his papers are the following:—On the geographical distribution of the *Ranunculaceæ* in British America, 1857; on the geographical distribution of plants in the British possessions in North America, 1858; on the geographical distribution of *Cruciferæ* and of the genus *Allium*, 1859; sketch of the life of Douglas, the botanist, 1860; on the swans and geese of the Hudson's Bay Territories, 1861; on the genus *Lutra*, 1863; on plants collected by Mr. J. Richardson in British Columbia, 1878. In 1860 a report was prepared and published by Mr. W. S. D'Urban on the *Coleoptera* in Mr. Barnston's collection. Mr. Barnston published other papers in journals in Great Britain of which we have as yet no detailed information.

On motion of Mr. W. Muir, seconded by Dr. T. Sterry Hunt, the following resolution was passed:—

"On the occasion of the decease of George Barnston, Esq., a member of this Society and a contributor of valuable papers to its proceedings and specimens to the museum, and a former President, the Society desires to express its high estimate of his character and services, and its sympathy with the members of his family."

Mr. F. B. Caulfield presented to the museum a specimen of the male Grosbeak, and the President a series of graptolites.

The last ordinary meeting for the session was held on the 30th of April—the President occupied the chair.

The first business was the announcement by Mr. E. Murphy, of a very fine donation of stuffed birds from Mr. A. A. Jowett of Sheffield, England. The collection, which includes all the game birds of Britain, was prepared by Webster, the London taxidermist, and exhibited at the London Fisheries Exhibit, where Mr. Jowett purchased it, and has forwarded it per S. S. Grecian to Montreal, where it will form a very valuable addition to the Museum of the Society.

On motion of Rev. Dean Baldwin, the heartiest thanks of the Society were tendered to Mr. Jowett for his very handsome donation, and he was proposed as a corresponding member.

Mr. E Murphy, then presented a paper on the microscopic appearances of the mosquito.

Mr. Muir followed, giving the exact microscopical measurements of the organs of the tiny creatures under consideration, and after viewing specimens prepared, the meeting adjourned.

(The papers of Messrs. Murphy and Muir may be found on pages 463 to 466.)

THE ANNUAL MEETING

was held on the evening of May 18th ; the President in the chair.

THE PRESIDENT'S ADDRESS.

In closing the Session of this Society, perhaps the first thing in our thoughts will be the position of this old and useful body in relation to the place which Montreal has taken as an entertainer of those great popular scientific associations which have done so much for the extension and diffusion of knowledge in the Mother Country and in the United States. The first meeting of the Am-

erican Association for the Advancement of Science in Montreal in 1857 was largely the work of this society. The conception of the idea belongs, I think, to the late Sir William Logan and myself.and it was carried out through the medium of the organization afforded by this Society. The invitation came from us. A delegation from our Society presented it to the American Association at Springfield. and the nucleus of the committee consisted of our members. We were, it is true, nobly seconded by the great body of the citizens, and the local committee, as ultimately constituted, included all the leading men of Montreal. That meeting was one of the most successful in numbers and scientific interest held by the Association up to that time, and in looking back upon its results I cannot but feel that it formed an epoch in the scientific and educational life of this city. We had hoped that the benefits experienced here would have induced some of the other cities of Canada to follow our example. But it was left to Montreal again, after the lapse of 25 years, to invite the Association. grown greatly in the meantime in numbers and importance, to hold its annual meeting in Canada. The lapse of a quarter of a century had removed most of the men who were leaders in 1857, but others had filled their places. Our society had greatly improved its building and its collections, and marvellous development had taken place in our educational institutions, and especially in the University. Again the Natural History Society took the lead in the invitation, and aided materially in securing the success of the meeting; and we had the pleasure of knowing that again our Montreal meeting was second to none that had preceded it. More especially it was successful in attracting men from abroad in greater numbers than is usual in meetings of the American Association.

These meetings must not be regarded as representing the actual work of science. They are rather its efflorescence and display, bearing the same relation to its regular labor that the public examination of a school at the end of its session bears to the daily fag and grind of the teachers and pupils throughout the year. Still such meetings do much good. They bring scientific workers together, enable the younger and less known to find access to those who occupy higher places, permit the friendly comparison and conflict of opinions, and enable the unscientific public to know something of what is occupying the attention of scientific students. They bring out, also, into prominence the march of

science from year to year, and do much to show its value as a means of education and as a pioneer to wealth, industry and prosperity.

Our good city has now taken a more ambitious flight in proffering its hospitality to the British Association for its meeting of 1884. I say more ambitious, not so much in reference to the standing and character of the Association itself as in reference to the difficulties to be overcome. I do not assert that the leading members of the British Association individually stand higher than those of the American, and perhaps there is as large an amount of good scientific work represented in the one society as in the other. But the American Association is at our door, the British is far away. Though living under a different Government, American men of science scarcely at all regard this in their intercourse with Canadians. In so far as science and literature are concerned, we are practically one, and there are many things in common in our circumstances and surroundings which bring more closely together those who have alike been colonists in a new country, than either can to the more conservative and established ideas of a Mother Country. Hence it is more difficult to induce the Englishman to see any propriety in transferring one of his great institutions to a colony than for the American to cross over an imaginary political line. Besides, the Atlantic with its waves and its sea-sickness is much more than an imaginary line, and the transportation of a large society across it, involves pecuniary outlay as well as personal risk and inconvenience. We need not wonder, therefore, that there should have been much hesitation in accepting an invitation so novel and involving so many untried contingencies. The fact that four hundred members of the Association, including many of its ablest men, have already signified their wish to attend the meeting in Montreal, should be taken by us as a testimony that the old spirit of adventure is not dead in the Mother Country and that scientific men at least appreciate what we can do in the Colonies. Let us hope that the intended meeting may be in the highest degree successful, and may be of the greatest service to the still infant cause of science in this country.

Death has removed several of our members in the past year. Of two only do I need to say a few words. Mr. Barnston was one of our true and earnest cultivators of natural science, one of those men who, banished into remote and uncultivated districts,

are attracted by the aspects of nature, and instead of allowing their minds to rust away in inaction turn themselves to the investigation and study of natural facts. Mr. Barnston was a typical man of this class, and has left in the pages of our journal and in our museum the evidence of his zeal as a naturalist. We have already recorded some features of his life and our estimation of his character. The aged are passing away; let us hope that younger men are rising up to take the places which they leave vacant. Another former president and long-tried and valuable friend of the society whom death has removed, is the late Rev. Dr. De-Sola.

In connection with this I would remind the Society of the appeal made to us by the Rev. Mr. Campbell, to aid in erecting a monument to the memory of our benefactor the Rev. Mr. Sommerville. Such men are few and deserve commemoration, and it may be well to think also of the fact that, in bearing them in remembrance, we stimulate others to like noble deeds. Among the many ways open to those who desire beneficially to connect their names with the real progress of this country, none is more fruitful than to follow in the footsteps of Mr. Sommerville, and to aid societies like this in educating the people by free popular lectures. Our treasurer, Mr. Marler, was authorized to receive contributions to the monument to Mr. Sommerville.

Of the scientific work of the session a more than usual portion has related to zoological science. Taking the last first, a very interesting subject was opened up, but by no means exhausted, by the contributions of Mr. Muir and Mr. Murphy towards the anatomy of the suctorial organs of the mosquito. Structures of this kind, imperfectly examined at a time when microscopes were less serviceable than at present, are described in the same terms by one naturalist after another till the imperfections of their descriptions attract attention, and new investigations are made, often leading to unexpected results.

The remarkable modifications by which the mandibles and maxillæ of the typical mandibulate insects become specialized into lancets and tubes for suctorial purposes merit more attention than they have hitherto received, and appear to present a vast variety of contrivances of the most perfect and complex character. It is perhaps, some compensation for the annoyance which these organs cause to us, that we find them to present so elaborate indications of thought and skill when we make them the objects of careful investigation. I may add here that there is scarcely

anything in the structures of animals and plants that when made the subject of microscopic study is not capable of furnishing the material of thought and improvement, and I trust that the Microscopical Club will frequently send in to this society such evidences of its life and vigor as were presented in this paper.

We were indebted to Mr. Fowler for the exhibition of a very interesting series of drawings of fishes, prepared by him for the international exhibition in London. No method of illustration of our fishes is better than such faithful drawings as those of Mr. Fowler, and I have no doubt they will be as much appreciated and admired by the visitors to the exhibition as by the members of our society. In preparing these drawings Mr. Fowler has had his attention called to many varietal forms and other peculiarities of our fishes, an account of which he will, I hope, one day present to us.

Our attention was directed to the analyses of soils by Dr. Edwards. This is a subject which has received far too little attention in Canada, and since the now somewhat distant time when Dr. Sterry Hunt was commissioned by the Geological Survey to analyse the exhausted and virgin soils of some typical districts of this country it has been much neglected. It is time, in the interests of agriculture, that the Government should appoint a chemical commission to collect the facts as to the exhaustion of soils and present them to the public.

Geology, as usual, occupied a prominent place in our proceedings The discovery of the bones of a whale at Smith's Falls in the post-pliocene gravel, and at an elevation of more than 400 feet above the sea, bears remarkable testimony to that submergence of the continent in the glacial age of which we have so many indications. Dr. T. Sterry Hunt occupied one of our evenings with an elaborate account of the state of the controversy relating to the age and relations of the Taconic rocks. The battle about the ages and subdivisions of the older crystalline rocks still rages fiercely and the most extreme views are expressed. Only a few days ago I found in *Nature* a report of a paper by Mr. Geikie the director of the Geological Survey of Great Britain, in which he utterly set at nought the divisions of Dimetian, Arvonian and Pebidean applied by Hicks to sucessive series of pre-cambrian rocks. How it will end is not possible to divine. In the mean time we are much indebted to Dr. Hunt for his masterly statement of the points at issue in one department closely connected with the main subject.

I must not forget thus publicly to thank Prof. Lockwood, of Princeton, for his kindness in making up our record of earthquakes for our proceedings. It shows, like former reports, some remarkable connections of earthquakes with certain seasons of the year, and also their connection locally with the junction of the Laurentian with the newer formations.

An interesting communication by one of our younger members was that of Mr. Walter Ferrier on new forms of animal impressions from the Potsdam sandstone. In connection with this I should say here that the similar impressions from Gaspe, referred to at the meeting, had been named in a paper read last spring by Mr. Whiteaves, but not yet published, *Gyrichnites*, a name which would also apply to Mr. Ferrier's specimens.

The small number of original contributions made to this society is a matter for much regret. We need to cultivate scientific writers, whether from among our own young men or from abroad. There is no doubt that in the comparative absence of men of combined culture and leisure, and in the heavy pressure of business on all our younger men, scientific research cannot greatly flourish, but there is the more need for its cultivation and encouragement by such societies as this.

We have to thank the newly constituted Royal Society of Canada for inviting us to send a delegate to its annual meeting. One of our younger scientific men has been chosen to this office, and he will present to the Royal Society a short notice of our scientific work during the session.

In conclusion allow me to say that while I regret that it is probable I cannot be present at any of the meetings of this society next winter, and while on this account I deem it right to decline being a candidate for re-election as president of the society, I hope that I shall be able when absent, occasionally to contribute notes and specimens to the meetings, and that on my return I may be able to advance the interests of the society with renewed vigor, and perhaps with more leisure for scientific pursuits.

Mr. G. L. Marler then read the

REPORT OF THE CHAIRMAN OF COUNCIL:

The year now closing has been one of exceptional character in the history of the Society, the invitation to the American Association for the Advancement of Science having been accepted, and the meeting of that body for 1882 held in this city. This meeting brought together a large concourse of the scientists of America, and a number also from Europe. The American Forestry Congress also met in this city and received the assistance of our Natural History Society.

As the result of the meeting of the Forestry Congress we have to chronicle the formation of a Canadian Association under the name of "Forestry Association of the Province of Quebec, Canada," and of the proclamation by the Provincial Government that a day in the month of May be devoted to tree planting and called "Arbor Day." As the result of our invitation together with that of other bodies we hope to take part in entertaining the members of the British Association in August, 1884.

Fourteen new ordinary members were elected during the year, and one corresponding member. We have to regret that the Society's ranks have been depleted by the death of several old members—Sir Hugh Allan, George Barnston, Dr. De Sola, James Court, M. H. Sanborn and David Greenshields.

The usual course of Somerville lectures was given to the number of six, as follows:—

1883.

Feby. 1st. "A Sketch of the Life and Bequests of the Rev. James Somerville, founder of these lectures." By Rev. Robert Campbell, M.A.

Feby. 8th. "Life Forces in Health and Disease." By Dr. John Wanless, L.F.P.S, &c.

Feby. 15th. "Notes on a Tour in the White Mountains." By Prof. P. J. Darey, M.A., B.C.L.

Feby. 22nd. "How Rocks are formed." By J. T. Donald, M.A., F.C.S.

March 1st. On "The Athabaska McKenzie Basin." By Robert Bell, M.D., LL.D., F.G.S.

March 8th "The Geology of the Old and New World compared." By T. Sterry Hunt, LL.D., F.R.S., &c.

These lectures attracted large and appreciative audiences and afforded to those present much pleasure and profit.

Your Council would recommend that hereafter ten lectures be given in this course on some popular subjects of natural history.

The thanks of your Society are hereby tendered to the gentlemen who so kindly delivered the lectures for this year and also to those who contributed to the Museum during the year, and especially to Mr. A. A. Jowett, of Sheffield, England, for his handsome donation—a case of British game birds. Over two thousand persons visited the Museum during the year and nearly all free.

Your Council has also to thank Mr. Charles Gibb for the kind invitation extended during the past year to visit his country residence at Abottsford, and to regret that the weather was so unpropitious that they could not avail themselves of his proffered hospitality.

Your Council has to regret the continued illness of Professor F. W. Hicks, the recording secretary, and to thank Dr. Edwards for having kindly acted in that capacity during the absence of Mr. Hicks.

Your Council would recommend to their successors that a revised list of members be printed in the *Naturalist*, and that the Society's exchange list be revised for the forthcoming edition of the Society's transactions, which will be published by Messrs. John Lovell & Son, for the Society.

Mr. Marler also presented

THE TREASURER'S REPORT AND FINANCIAL STATEMENT.

During the past year numerous improvements have been made in the building. The ceiling of the library has been decorated, additional shelves have been put up and a new carpet placed on the floor. A new furnace has been placed in the building, the amount due Dawson Bros. and the arrears of taxes have been paid and there remains on hand a balance of $192.18, with the Government grant for 1883 yet intact.

FINANCIAL STATEMENT.

G. L. Marler, Treasurer, in account with The Natural History Society of Montreal, from May 19th, 1882, to May 18th, 1883.

Dr.		*Cr.*	
1882. May 18.		1882 and 1883.	
To Balance on hand	$156.09	By Printing and Advertising	$113.90
" Government grant	700.00	" Gas account for year	82.78
" Rent of Rooms	550.00	" Additions to Museum	12.75
" Entrance fees to Museum	29.48	" Editing *Naturalist*	30.00
" Members' Fees	504.00	" Bookbinding	109.50
" Donations	20.00	" General repairs	80.03
		" Stationery, Books, Postage, &c	17.50
		" Salary to J. Potts	264.43
		" City Water Works account	24.70
		" New Furnace	150.00
		" Wood and Coal	84.05
		" Insurance	30.00
		" Dawson Bros. account	276.22
		" Thomas Mussen (carpet)	97.85
		" City Taxes (two years)	255.65
		" Petty disbursements	44.03
		" Tinting, decorating, &c	94.00
		" Balance	192.18
	$1959.57		$1959.57
To balance brought down $192.18			

Mr. Wm. Muir then presented the

REPORT OF THE CABINET KEEPER AND OF THE LIBRARY COMMITTEE.

1st. Work on the Building.—The museum and library room have been cleaned, the ceilings and walls tinted and the library floor carpeted. In the lecture room and halls the ceilings have been tinted and the walls blocked in imitation of stone.

The old furnace has been replaced by a very superior one capable of heating the whole building.

2nd. Work in the Museum.—W. F. Ferrier, Esq., has devoted much time to arranging the mineralogical specimens, cleaning the cases and improving the appearance of the specimens by placing them in suitable boxes. The Society is indebted to Mr. Ferrier for his valuable services. Mr. F. B. Caulfield has also devoted much time to the care and improvement of the insect collection, he reports as follows:

"The specimens of Canadian Lepidoptera purchased by the Society from me are one hundred in number, viz.:

Butterflies 2, *Sphingidae* 1, *Bombycidæ* 11, *Noctuidæ* 52, *Geometridæ* 34.

During the session the specimens have been taken out and cleaned, the drawers repapered and the specimens replaced, leaving room in the drawers containing Canadian insects, for the reception of species wanting in the collection.

The cabinet contains a fair series of Canadian insects, arranged in the following order:

Canadian Coleoptera (beetles)	4 cases.
British Columbian Coleoptera (beetles)	1 "
Canadian Lepidoptera (butterflies & moths)	8 "
British Lepidoptera (butterflies & moths)	3 "
British Coleoptera (beetles)	1 "

The remaining cases contain exotic insects, principally Coleoptera, from South America, Africa, India, &c.

The orders *Orthoptera*, *Hemiptera*, *Diptera* and *Neuroptera*, being almost entirely wanting in the cabinet, I have reserved two drawers for such specimens as may be procured from time to time.

With the exception of the exotic species, on which I am working at present, the work is finished, and the collections are clean and free from insects pests."

The following is a list of donations to the museum during the year with the names of donors:

Pine Grosbeak *Pinacola Canadensis*, Car. By F. B. Caulfield, Esq.

Western Meadow Lark, (Manitoba) *Sturnella Magna*. By A. D. Ross, Esq.

Pigeon Hawk (Manitoba), Falco Columbarius Var. By A. D. Ross, Esq.

Canadian Sponge. By Prof. Fowler.

Two bottles of insects, Scorpions, &c. By R. Holwell, Esq, Kington, Jamaca, W. I.

Case British Game Birds, by A. A. Jowett, Esq., Sheffield, England, contains the following:

Common Partridge, *Perdix cinereus*,	male	and	female.
Red-legged Partridge, *Caccabis rufa*	"	"	"
Migratory Quail, *Coturnix communis*,	"	"	"
Capercaillie, *Tetrao urogallus*,	"	"	"
Black Grouse, *Tetrao tetrix*,	"	"	"
Red Grouse *Lagopus scoticus*,	"	"	"
Common Ptarmigan *Lagopus vulgaris*,	"	"	"

Specimens Pyroxene from near Calumet. By John Thornton.

18 Specimens Graptolites. By Principal Dawson.

37 Specimens, various Minerals. By a lady friend.

3. Report of the Library Committee.—During the year one hundred and ninety-three volumes of perodicals and pamphlets have been bound and placed in the Library.

A large number of works have been received during the year, list of which will be published in a future issue of the Society's journal.

Mr. J. T. Donald submitted the

REPORT OF EDITOR OF "CANADIAN NATURALIST."

During the year now closing four parts of the *Naturalist* have been published and a fifth will be issued as soon as the proceedings of the annual meeting are available for publication. The Editor has attended to the mailing of the Journal to exchanges and delivery of same to members with satisfactory results as there are now no complaints that the *Naturalist* is not received by those entitled to it.

In view of the publication of a Journal to take the place of the *Naturalist* which will not appear after the issue of the part now in press, it is respectfully suggested that a Committee be appointed to revise the exchange list, and that the Editor be empowered to take the oversight of mailing and delivery of the

Society's Journal, and to acknowledge receipt of exchanges, and that a book and printed forms for that purpose be placed at his disposal.

Mr. A. A. Jowett of Sheffield, Fngland, was elected a corresponding member.

THE ELECTION OF OFFICERS.

The election of officers was then proceeded with and resulted as follows:

President—Dr. T. Sterry Hunt.

Vice-Presidents—Mr. J. H. Joseph, Prof. P. J. Darey, Major H. Latour, Rev. Dean Baldwin, Dr. Hingston, Prof. B. J. Harrington, Mr. D. A. P. Watt, Rev. R. Campbell and Dr. Dawson.

Recording Secretary—Mr. G. Summer.

Corresponding Secretary—Dr. J. Baker Edwards.

Treasurer—Mr. G. L. Marler.

Cabinet-Keeper and Librarian—Mr. Wm. Muir.

Council—Messrs. J. T. Donald, J. Bemrose, Dr. Osler, M. H. Brissette, John S. Shearer, J. H. R. Molson, W. F. Ferrier and E. Murphy.

Library Committee—Messrs. W. Muir, J. Bemrose, E. T. Chambers and Dr. McLaren.

Editor of Canadian Naturalist—Mr. J. T. Donald.

Mr. E. MURPHY moved a vote of thanks to the retiring officers, and to Dr. Dawson especially, which was carried unanmiously.

Dr. DAWSON thanked the Society for the cordial vote of thanks, and the meeting was adjourned.

MISCELLANEOUS.

METEOROLOGICAL RESULTS FOR THE YEAR 1882.

McGill College Observatory Montreal, Canada. C. H. McLeod, Superintendent. Height above sea level, 187 feet.

MONTH.	THERMOMETER.				* BAROMETER.				†Mean Pressure of Vapour.	‡ Mean relative humidity
	Mean	Max.	Min.	M'n d'y Range.	Mean.	§ Max	§ Min.	M'n d'y Range.		
January	12.20	42.4	-26.0	17.68	30.1047	30.881	29.144	.4142	.0711	79.8
February	21.04	46.2	- 8.5	15.37	30.0903	30.999	29.582	.3529	.0934	74.0
March	25.05	47.0	1.4	15.23	30.0474	30.743	29.230	.3322	.1046	69.7
April	35.57	57.2	13.1	14.07	29.9719	30.605	29.190	.2149	.1450	68.7
May	49.68	67.5	27.1	18.02	29.9932	30.482	29.526	.1865	.2019	56.6
June	62.72	86.7	43.9	17.24	29.7999	30.246	29.339	.1514	.3766	65.5
July	67.64	84.9	50.8	15.21	29.9006	30.280	29.500	.1180	.5054	75.7
August	68.34	91.0	48.0	17.72	29.9597	30.311	29.500	.1318	.5037	72.7
September	58.21	79.1	40.6	14.79	30.0616	30.413	29.295	.1621	.3799	75.2
October	49.43	74.7	30.5	15.09	30.0587	30.380	29.611	.1635	.2653	71.5
November	31.36	60.6	14.3	11.24	30.1124	30.582	29.529	.1708	.1390	77.0
December	17.67	37.1	- 5 3	12.54	30.0328	30.561	29.396	.2200	.0923	86.4
Means for 1882	41.576	......	......	15.35	30.0111	......	......	... .	.23985	72.73
Means for 8 years ending with '82.	42.501	.....	.....	....	29.9694	......	......	....	.25477	73.97

MONTH.	WIND.		Sky clouded per cent.	Percentage of Possible Sunshine
	Mean velocity in miles ℔ hour	Mean. direction.		
January	14.15	W. by S.	58.7	44.1
February	13.17	N. W.	47.3	49.7
March	12.35	N. W. by W.	50.1	53.0
April	11.88	N. W. by N.	63.9	46.6
May	11.40	E. N. E.	57.0	50.0
June	10.55	W. S. W.	51.3	60.1
July	10.15	W. by S.	53.2	62.8
August	7.62	N. W. by W.	46.8	68.4
September	8.31	N.	58.0	53 1
October	10.02	W. S. W.	49.9	57.5
November	9.30	N. W.	64.7	40 1
December	11.04	W. S. W.	78.7	25.0 (?)
Means for 1882	10.83	W. N. W	56.63	50.87
Means for 8 years. ending with December 31st. 1881	11.054	W. by S.	61.41	....

* Barometer reduced to 32° Fah. and to sea level.
† Inches of mercury. § Observed.
‡ Relative saturation being 100.
The monthly means are derived from observations taken every fourth hour beginning with 3.13 a.m. (The mean sunshine given for December is not from a record, but was estimated from the mean of clear sky observed.)

The greatest heat was 91.0 on August 6th; the greatest cold was 26.0 below zero on January 24th; extreme range of temperature for the year 117°; greatest range of thermometer in one day was 37.°0 on February 17th; least range of thermometer in one day was 4.4 on November 20th; the warmest day

was August 6th, the mean temperature (from max. and min.) being 82.°7; the coldest day was January 24th, the mean temperature being 18°.1 below zero; highest barometer reading was 30.099 on February 18th; lowest barometer reading was 29 190 on April 28th, giving range of 1.809 inches; the lowest relative humidity was 18 on May 17th. The greatest mileage of wind recorded in one hour was 49 on January 22nd; greatest velocity was at the rate of 64 miles per hour, on January 22nd. (This is the greatest velocity recorded here during eight years—the greatest previous velocity, during this period was 60 miles per hour on February 2nd, 1876.)

Notes.—The sleighing of the winter closed on March 27th. The first snow of the autumn fell on November 14th, but was inappreciable; the first appreciable snow fell on November 25th. The first river craft arrival in port was on April 11th. Ferries began running on April 13th. Navigation open on April 27th. Auroras were observed on 52 nights. Lunar coronas were observed on 8 nights; solar halos on 18 nights; solar halos on 5 days, accompanied by parhelia on 2 days; hoar frost on 21 days; fogs on 20 days; thunder storms on 21 days, and lightning, without thunder, on 9 days. Earthquake tremor on October 10th, at 4.50 a.m. The zodiacal light was observed once.

RAIN AND SNOW FALL DURING 1882.

MONTH.	Inches of rain.	No. of days on which rain fell.	Inches of snow.	No. of days on which snow fell.	Inches of rain and snow melted.	No. of days on which rain *and* snow fell.	No. of days on which rain *or* snow fell.
January	1.18	4	28.2	20	3.90	3	21
February	0.58	4	23.2	13	2.87	0	17
March	2.46	8	15.3	15	4.41	3	20
April	1.58	11	3.2	5	1.85	1	14
May	1.50	15	0.5	1	1.55	0	16
June	4.74	20	0.0	0	4.74	0	20
July	6.04	17	0.0	0	6.04	0	17
August	2.52	11	0.0	0	2.52	0	11
September	3.63	12	0.0	0	3.63	0	12
October	1.34	14	0.0	0	1.34	0	14
November	1.39	14	1.0	5	1.46	1	14
December	0.04	3	39.8	24	3.95	1	26
Totals	27.00	133	111.2	83	38.26	9	202
Means for eight years ending with 1882	27.04	137.0	113.7	85.3	38.48	16.1	205.5

Hail fell one day in June, one day in October and two days in November.

PUBLISHERS' NOTICE.

With the present number the publication of *The Canadian Naturalist and Geologist* will be discontinued.

A few complete sets of the First Series in eight volumes still remain. These volumes contain many important original papers contributed by the first editor, the late Mr. E. BILLINGS. Price for the set $16.00.

Of the Second Series several of the volumes are out of print. Those which remain will be sold at $3.00 per volume.

The Transactions of the Natural History Society will be published in form similar to *The Canadian Naturalist* by Messrs. John Lovell & Son, for the Society, as announced on page 476.

INDEX.

Date Due

~~4 Jan 51~~	
~~6 Mar '51~~	